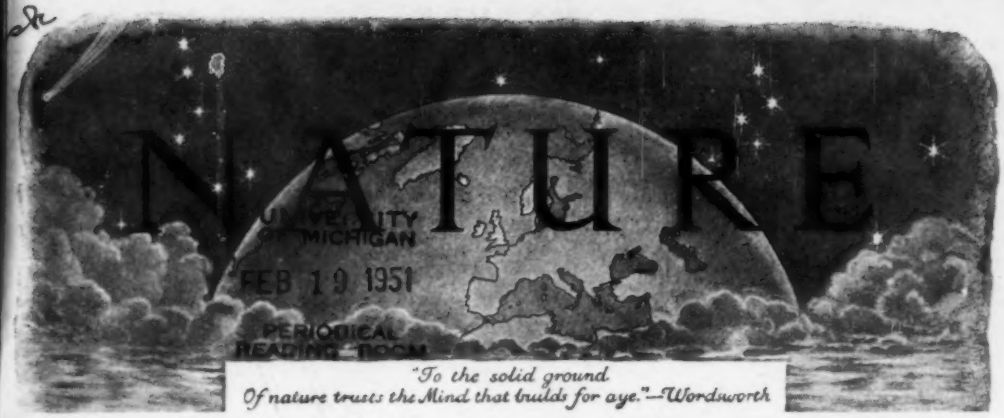

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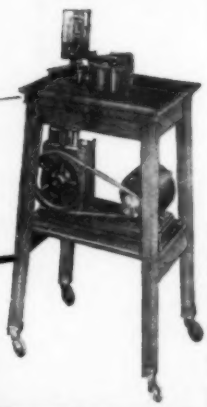

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THE UNIVERSITIES AND ADULT EDUCATION

ALL the universities and university colleges of Great Britain have defined areas within which they are responsible—in collaboration with local education authorities, the Workers' Educational Association, and other bodies—for providing educational services to adults. Large sums of money are spent upon these extra-mural activities, and many members of staff, both full-time and part-time, take part in them. Yet their nature and extent are often imperfectly understood, and, in a recent article, Mr. W. E. Salt, director of the Department of Adult Education in the University of Bristol, tries to sketch the growth and present extent of the universities' concern in adult education (*Univ. Rev.*, 23, No. 1, September 1950).

It was in the 'seventies that the universities as institutions began to recognize responsibilities to the communities outside their walls. Before that time individual members had often taken part in the contemporary movements for adult education. An example is that of Dr. George Birkbeck, whose lectures to mechanics in Glasgow at the opening of the century are thought to be the forerunner of the mechanics' institutes.

The stirrings of new life in Oxford and Cambridge about the middle of the century caused them to look abroad, and several schemes, grouped under the phrase 'university extension', were proposed for carrying the university to the people. They were first given practical effect and support by Cambridge, which, in 1873, adopted Mr. James Stuart's suggestion and organized a number of lecture centres. These were followed by London and Oxford in 1876 and 1878; in 1914, all the universities of England and Wales had their extension schemes.

As time went on, however, many students, particularly those drawn from the trade union and co-operative movements, felt that extension lectures did not wholly satisfy their needs. They wanted, not courses of lectures, but an opportunity to make a continuous and searching study of some subject. This involved a class, restricted in size, meeting regularly over a fairly long period and led by someone who would be a tutor rather than a lecturer. The Workers' Educational Association, founded in 1903, pressed this point of view and took the initiative in convening a conference at Oxford in 1907. Out of it came the three-year tutorial class which is still the finest flower of British adult education. The two historic tutorial classes, begun at Longton and Rochdale in 1907, multiplied to 145 in 1914.

In 1919 appeared the important final report of the Adult Education Committee of the Ministry of Reconstruction. The Committee concluded that the assumption by universities of new responsibilities for the higher education of adults had not been the result of any deliberate re-consideration of the principles and objects of university education. It had been undertaken piecemeal in response to the demands of particular groups of students. In the opinion of the

Committee the period of experiment was over. It was convinced of the depth and persistence of the demand for adult education and argued for a correspondingly bold and generous use of university resources. From many recommendations, three may be mentioned :

1. The provision of a liberal education for adult students should be regarded by universities as a normal and necessary part of their functions.

2. Their expenditure on the promotion and provision of adult education should be largely increased.

3. Universities should establish departments of extra-mural studies, with academic heads and adequate staffs.

In the following years, all these recommendations were carried out.

The two decades between the World Wars was a period of substantial growth, in which established types of work were carried much further and ventures were made into new fields. The emphasis continued to be upon courses of study and upon the repair of defects in earlier education.

The Second World War was a severe test of the tenacity of students and the resilience of extra-mural departments. The remarkable feature was that the unavoidable recession—greater in some areas than others, because of the unequal impacts of the War—was everywhere so limited. Indeed, the work done by universities for adults actually increased because they were called upon to play a prominent—in some places, the dominant—part in the civilian contribution to Services' education. Surprising numbers of lectures, courses and classes were arranged for all types of groups, varying in size from the small searchlight detachment to a whole ship's company. The end of the War found adult education in Great Britain in much better shape than it had been in 1918.

In the past four years, adult education has sprung forward after the temporary setback of the War. Several influences have spurred it on. Universities have formed closer ties with their regions, and, while drawing in from them students and resources, have felt more keenly the responsibility to give out intellectual guidance. The Education Act of 1944 made it an obligation upon local education authorities to provide comprehensive schemes of further education and enjoined them to collaborate with universities in the task. The Ministry of Education, a generous supporter of adult education before the War, made development easier by introducing even more liberal and elastic regulations governing grant-aid. The University Grants Committee, too, gave its approval and support to schemes of expansion. The effect of these influences has been a noteworthy widening of the scope of extra-mural activities.

No two areas show exactly the same trends or rate of growth. Regions differ in their social characteristics and populations, and universities in their policies and resources. But underlying these divergencies there are several common features. The extra-mural programmes of all universities show the following activities, although they may be compounded in different proportions :

1. *Classes in liberal studies.* Three-year tutorial classes have more than held their own, and to them has been added a large number of courses running for a single session.

2. *Lecture courses.* Extension lectures, which had suffered a relative decline between the Wars, have revived.

3. *Specialized courses.* There are many people with specialized interests, mostly—though not all—based upon professional groupings. Universities have, therefore, arranged an increasing number of courses for such groups, mostly of a postgraduate standard. Internal departments have joined with adult education departments to give teachers, engineers and industrial scientists—to mention only a few examples—refresher courses and accounts of recent advances and researches.

4. *Residential adult education.* The summer schools, so highly successful in pre-war days, have been re-opened and extended, and give large numbers of men and women an opportunity of continuous guided study for periods of one or two weeks, or longer.

5. *Services education.* In the past year, universities, which were the mainstays of the war-time Regional Committees for Education in H.M. Forces, have, at the request of the Service Departments, assumed a more direct responsibility for the provision and co-ordination of education for men and women in the Forces.

This summary shows how varied the extra-mural functions of the universities have become and serves as a basis for the discussion of problems of policy and administration. Some of them are primarily administrative and raise no questions of principle. Others involve the whole attitude of the university towards its extra-mural constituency.

The question whether universities should engage in adult education at all is still sometimes debated. The latest report of the University Grants Committee mentions the persistence of doubts concerning the quality of much extra-mural work and the difficulty of integrating it fully into the life of the university. Both points have their force, but scarcely enough to warrant an adverse verdict. As long as universities are teaching institutions and not just monasteries of learning, still more if they wish to become intellectual foci of their regions, they cannot ignore the needs of those members of the surrounding community who are unable to enter the walls.

The conclusion that adult education is a normal function of a university leaves unresolved the problem of the scope of the work which can be properly and effectively undertaken. Universities should not be universal providers, seeking to satisfy all demands ; but it would be difficult to say where the limit should be set. Each university decides its own policy, and the makers of policy do not speak with one voice. It has been suggested that education in extra-mural courses should be limited to students who have passed their preliminary courses or can satisfy certain general educational requirements. This would exclude many promising students, and Mr. Salt suggests that the course itself provides the best test ; it should make such demands that only the serious student is willing to accept its discipline.

Similarly, it is impossible to define the scope of extra-mural studies in terms of the ultimate objective of the courses provided. Some courses are intended to prepare for an academic diploma or certificate. One can, in such cases, readily judge the suitability of a syllabus and can test the response of students by examination. But courses of this kind are few. The great majority have no such specific end. They are intended, not to prepare for an examination, but to develop minds and personalities. When the goal is so indeterminate, there is no simple criterion by which to judge whether the course is appropriate to a university or whether a particular student is likely to benefit by it.

Thus, while the factors of duration and student attainment must be taken into account, they give little help to the formulation of policy. Extra-mural committees and staffs must approach the task of building up programmes without hard-and-fast principles to direct them.

Secondly, all that a university does should be of high academic standard. This is partly a matter of the scholarship of the lecturer or tutor. It need scarcely be said that a university should be jealous of the quality of the teachers who represent it to large sections of the general public. So far as members of the university staff are concerned, there is no serious problem; it is when, with the spread of the work, recourse is had to part-time tutors that the danger of uncertain standards creeps in.

Another problem of some complexity is that of the relation of a department of adult education to the university as a whole. If the work of this department is to be truly an extension of the university, it must be an integral part of the university body. If it is not, if it does not reflect outside the walls the standards and traditions which prevail within, then it does not contribute anything which could not be as well supplied by other bodies. Here it follows that as much as possible of the extra-mural work should be done by members of the internal staff. They are the core of the university, and who can better transmit to the outside world the intellectual attitudes and ideals of a university than those who are their guardians?

But complete reliance upon internal resources would very straightly restrict the scope of the work. Internal lecturers have neither the time nor—very rightly—the inclination to undertake more than a limited number of outside commitments.

Full-time extra-mural staffs are necessary, if only to provide a firm foundation for the local scheme and to ensure that centres remote from a university are served. The right balance between the use of internal and full-time extra-mural staffs will be affected by the volume of the work and by geographical and transport factors; but decisions about the relative strengths of full-time and part-time staffs should not be made solely on grounds of administrative convenience.

There is also the problem of ensuring that the full-time tutor shall feel himself to be truly a member of his university. This is not merely a question of status, but how to secure that the full-time tutor, resident maybe forty or fifty miles away, lacking regular contacts with fellow-students, working in isolation with groups which may rarely come under the guidance of other teachers, is made to feel that he is one of the university community, responsible for representing its ideals and policies and able to draw help and encouragement from the centre.

Mr. Salt also touches upon the problems for university extra-mural departments raised by the Education Act of 1944, which places upon local authorities the duty of ensuring that "adequate facilities for further education" are provided. From having powers, they now have duties. This change means two things: local authorities will become larger providers of further education than ever before, and they are now trustees, as it were, for their citizens, charged with ensuring that comprehensive educational facilities are available. This will involve close liaison between the universities and the national system of education.

THE LIFE OF VERTEBRATES

The Life of Vertebrates

By Prof. J. Z. Young. Pp. xvi+767. (Oxford: Clarendon Press; Oxford University Press, 1950.) 42*s*. net.

THIS is perhaps the best text-book of vertebrate zoology that has yet been written, and as there are already several good text-books on the subject, this distinction has not been easily achieved. The prefaces of most text-books take pains to make clear the didactic principles on which the books were written—the need for animating structure by some reference to function, maybe, the evidence of design in the workings of Nature, the documentation of the evolutionary process, the philosophic wholesomeness of the organism as a whole, and so on. Prof. Young's expressed intention is to treat of the *life* of vertebrate animals in its most complete synoptic sense: its origin and secular changes of complexity, the means by which animals cope with the hazards and exigencies of living and staying alive, the varieties of truce that accommodate the chronic enmity of the environment, and everything else that is entailed by the act of living. The scheme as a whole is one the merits of which scarcely admit of argument, given the knowledge and grasp to see it through. Prof. Young evidently has these qualifications, for no other text-book of vertebrate zoology has quite the same compass or synthetic power or so easily handles the concurrent time-scales of eons and generations, years and days and minutes. Yet his book is most easily and enjoyably readable, and has fewer passages of *recitativo secco* than one expects to find in a work that is obliged to be so largely descriptive in its make-up.

The way in which Prof. Young deals with the Amphibia will illustrate his method. First, he describes the peculiar advantages of lungfish-like animals in the drying waters of Devonian times and shows how the modern Amphibia may well have taken origin from them. There follows a conspectus of early and extant forms and their varieties of habit and habitat, a survey that is greatly filled out in the succeeding chapter. The skin and its coloration are then dealt with fully; but it is the section on the skeleton and muscular system that illustrates the

power of his method best. The section is lengthy and anatomically quite detailed; but it is never gratuitously anatomical. The skeletons that are described are of animals that squat or jump or swim or wriggle, that have to face the new problems of four-footed locomotion and of raising their bodies from the ground. Respiration, circulation, behaviour and the nervous system are dealt with in the same spirit: this is not functional morphology or physiology with an anatomical substratum, but a form of treatment that challenges the appropriateness of the conventional distinction between the two.

The second of the two chapters given to Amphibia describes their evolution and adaptive radiation, and one ends with a better grasp of the biology of Amphibia than other text-books have yet contrived to provide. Much use is made of very competent drawings throughout, sometimes to give a hint of an animal's characteristic surroundings, sometimes to illustrate adaptive radiation and species differences, but most often simply to show the reader what a particular animal looks like. Indeed, animals peer at the reader or at each other all through the book. The ill-informed reproach that the study of animals is now unfashionable among zoologists can now be finally silenced.

It is characteristic of the author's manner of thought that a long chapter should be given to fishing and fishing problems and the food-cycles of the sea, which have a certain massive simplicity and grandeur. If one asks, why fishing rather than livestock raising, the answer is simply that fish are the only wild animals used in important quantities for human food. Formal embryology is not included; a modern text-book of comparative embryology remains, therefore, a most urgent need. Its omission was clearly a matter of policy, but there are plenty of other omissions of matters of fact that one reader or another might rightly or wrongly hope to find. No doubt there are also a fair number of factual errors, the correction of which will give deep satisfaction to those who read the book with their detection as a principal motive. But by and large, this is a book which stands a very good chance of outliving its author; for, as with the physiologists' "Starling", the factual matter may be partly superseded: but the framework and the habit of thought that gave the facts their order deserve to linger on.

ELECTRICAL INTERPRETATION OF INORGANIC CHEMISTRY

Molecules and Crystals in Inorganic Chemistry

By A. E. Van Arkel. Translated by J. C. Swallow. Pp. ix+234. (London: Butterworth Scientific Publications, Ltd.; New York: Interscience Publishers, Inc., 1949.) 17*s.* 6*d.* net.

THE English translation of Prof. A. E. Van Arkel's book on "Molecules and Crystals in Inorganic Chemistry" will be of particular value to the chemist and crystallographer. Van Arkel was one of the pioneers in using an essentially electrical model of the atom to explain chemical phenomena.

In his book he has given a systematic account of inorganic chemistry based on these ideas. Fundamentally, he used as assumptions the existence of positive and negative ions variously charged and with definite atomic radii. He explains the structure and stability of molecules of extended crystal lattices by considering the electrostatic Coulomb energy between the charged ions. By making use of knowledge of ionization potential and electron affinities derived from electrochemical studies, it is possible in this way to calculate, in a very large number of cases, the energy of formation of a compound and to indicate, where he cannot do so, the relative parts of different structures. In this way he covers and extends the work of Pauling and Goldschmit. In later chapters he considers the particular position of the hydrogen ion existing within the electron cloud of other ions, particularly those of oxygen, and the effects of polarization. Van der Waals forces, covalent bonds and inter-metallic forces are mentioned but not developed.

The attractive feature of Van Arkel's view of chemistry is its coherence and its simplicity. By the use of an extremely simple hypothesis and no mathematics beyond that of adding and dividing, he is able to produce a quantitative picture of stability and energies of compounds which does not differ grossly from experimental values. He is able, as well, to explain many of the features of inorganic chemistry such as solubilities and volatility. In this way inorganic chemistry ceases to be a set of particular facts to be learned and remembered, and becomes a rational discipline to be deduced from first principles. The refinements of quantum theory would undoubtedly give a far more adequate picture of inter-atomic energies. This, however, is only possible by the use of the most refined mathematics, which achieves results of little greater accuracy. It would appear that the simple approach is of the greatest value for getting a general view over the field and particularly for introducing students to it, as long as they are carefully warned that this is not the whole story and that the finer aspects of chemistry, both of molecules and crystals, require much more detailed treatment.

The book will be of great value to chemical and crystallographical students and undoubtedly will form part of the revision of the elementary inorganic chemistry that is now in progress. J. D. Bernal

THE CHEMICAL ENGINEERS' BIBLE

Chemical Engineers' Handbook

Prepared by a Staff of Specialists. Dr. John H. Perry (editor). (McGraw-Hill Chemical Engineering Series.) Third edition. Pp. xv+1942. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 144*s.* 6*d.*

THE "Chemical Engineers' Handbook" has reappeared in a new shape, 8 in. × 6 in. as compared with 6 in. × 4 in., the pages being reduced in number from 3,029 to 1,942. The alteration is, in most respects, to be highly commended. The old edition was uncomfortably thick and with narrow margins, with the result that much of the subject-matter was difficult to read and many of the old charts were too small to be of much quantitative value. The larger pages make possible the provision of really useful diagrams, and the 2,081 figures have all been improved by printing from new blocks. Some of the tables have suffered in appearance by horizontal extension without appreciable vertical change, especially logarithms and the tables of physical properties. In the case of organic compounds, the long blank spaces might well be filled with values for the refractive index, a quantity often required for analytical purposes.

"Perry" would be a good answer to those who still ask the question "What is chemical engineering?" It deals with nearly all that a chemical engineer may want to know, whether in the form of numerical data, fundamental theory or the performance of plant. The quality is on a level with the quantity, since every article is written by an acknowledged expert in its subject-matter.

The book is still divided into thirty sections; but those on arithmetic, analytical chemistry and organic chemistry have gone. New articles on diffusional operations, furnaces, size enlargement and distillation are very welcome, while the rewritten section on process control deserves special mention for its clarity and conciseness. Any detailed review of the vast amount of material presented is impossible; it is easier to direct attention to a few minor defects in the hope that they may be eliminated in future editions.

A volume of this comprehensive nature is particularly liable to what may be called the persistence of obsolete data. An example is a table of sparking potentials taken from an American text-book of 1928. The actual figures appear to be mainly those of Warburg (1890) and Defregger (1903), which are quite unreliable. On the whole, however, the book is remarkably free from inaccuracies of this type, the authors having taken great pains to insert the most recent figures available and to give their origin.

The transfer of tables from other publications *en bloc* is not always desirable. The chemical engineer is not interested in the coefficient of expansion of the Jena thermometer glasses or of topaz (p. 201), whereas he might like to find some figures for refractories, which are only referred to in a very sketchy manner; values for the electrochemical equivalents of the rare gases (p. 1,776) are meaningless. In the section on materials of construction, the extensive tables with their liberal use of trade names could, with advantage, be greatly abbreviated, particularly in view of the very proper warning that corrosion figures are unreliable. A feature which it is hoped will not be developed further is the emphasizing of the names of makers of machinery rather than the principles of its operation. Certain subsections tend to resemble a collection of catalogues, and many of the illustrations give no useful information as regards constructional details.

Points such as these are, however, of quite minor importance, and the volume as a whole must be regarded as an admirable summary of existing knowledge which every chemical engineer will feel it is his duty to possess.

H. E. WATSON

NUCLEAR PHYSICS FOR THE NON-SPECIALIST

Einführung in die Kernphysik

Von Prof. Dr. Wolfgang Riezler. Vierte erweiterte Auflage. Pp. 309+8 plates. (Berlin und Buxtehude: Hermann Hübener Verlag, 1950.) n.p.

DR. RIEZLER's book is meant for the non-nuclear physicist, the student and the educated layman. It is descriptive and avoids any derivation of formulæ, though some of the more important relations are scattered throughout the text. The book is arranged as follows: properties of nuclei, natural radioactivity, nuclear transformations, basic ideas of the build-up of nuclei, together with systematics and a little theory. The second half of the volume deals with the methods used in nuclear investigations, such as the ways by which one obtains fast particles, neutron sources like the pile, and methods of detecting particles such as ionization chambers, counters and associated circuits, etc. A chapter on applications connected with the use of radioactive isotopes, a simple graphic representation of the radioactive isotopes and a glossary complete the volume. The book runs to about three hundred pages and contains most of what is noteworthy up to the spring of 1948. The presentation is, on the whole, clear, though the text is occasionally uninspiring. If a reader is supposed to follow through three hundred pages of text, it would certainly make it easier if the author had given an inkling of the dramatic developments which take place in science, and which sometimes, so to say, overnight, bring us an enormous step forward. A very good idea of what this means can be obtained from Pauli's contribution to the Bohr jubilee number in the *Review of Modern Physics*, where he deals essentially with the development of the quantum theory.

Since the volume is meant for laymen, Dr. Riezler has added a glossary. If, however, a reader has to look up the meaning of "ohm", "gleichrichter" or "kondensator", he has very little chance of getting further in this book than the introduction, since he collides later on with such formidables as the quadrupole moment, Larmor frequency, uranium Z and circuit diagrams with heaps of components. It is not the name, superficially explained in a line, which is hard to grasp, but the visualization of the meaning, which is often very difficult. Therefore, this glossary scarcely helps and might just as well be dropped in future editions.

There is a number of points about which I could quarrel with the author; here are a few selected at random. A minimum length is postulated in nuclear theory, on p. 144, but the Pauli principle, which is so fundamental for nuclear structure, is forgotten. Nothing is gained by giving three circuit diagrams of electronic scalers (pp. 209–11), nor is the linear amplifier without feedback representative of modern electronic design (p. 196). The positive ion sources in high-voltage equipment of to-day are almost exclusively low-voltage discharge tubes or radio-frequency sources and not canal ray tubes (p. 153). No nuclear research was done with the old linear multiple accelerator (pp. 153–4), though the modern version of Alvarez is quite successful. The great success of modern medium-energy accelerators is the linear accelerator for electrons, which is not mentioned.

Finally, the collection of names in the author's index makes strange reading. It often seems that the names have been chosen at random, leaving out well-established men of science such as C. D. Anderson, Blackett, Frisch, Meitner and others. To say that the relation $E = mc^2$ is, in the literature, referred to as Hasenöhrl's and sometimes as Einstein's is unfair, since I could not find this statement elsewhere though I went through several text-books, some of them in German. That Einstein's relation is the result of a new law of Nature and of universal validity, while Hasenöhrl's is from ordinary classical electro-magnetic theory and is no more than an interesting remark, seems to have escaped the author.

Some of the photographs at the end of the book are very unsatisfactory: the one of the cyclotron of the Collège de France is not good enough—it is out of focus.

E. BRETSCHER

Technique of Organic Chemistry

Edited by Arnold Weissberger. Vol. 3: Heating and Cooling, Mixing, Centrifuging, Extraction and Distribution, Dialysis and Electrodialysis, Crystallization and Recrystallization, Filtration, Solvent Removal, Evaporation and Drying. Pp. ix+661. (New York and London: Interscience Publishers, Inc., 1950.) 80s.

THIS volume surveys the techniques used in the isolation and purification of compounds, and is the third in an Interscience Series of which the first, dealing with the measurement of physical properties, is now well known.

The articles by the various authors differ greatly in length. The chapters on extraction and distribution and on crystallization and recrystallization occupy 142 and 122 pages respectively, that on solvent removal, evaporation and drying occupies thirty pages, and that on centrifuging requires merely twenty-eight pages. The selection of material for certain of these articles appears to have presented a difficult problem, and in some chapters a rather peculiar balance has been struck between chemical engineering theory and laboratory technique. For example, in the section on heating and cooling (98 pages) a short account is given of the chemical engineering approach to heat transfer theory, and later in the same article space is devoted to bunsen and other burners with descriptions and illustrations such as can normally be found in laboratory furnishers' catalogues. The chapter on filtration (120 pages) is similarly constructed.

The articles on extraction and distribution, written by L. C. Craig and D. Craig, and on crystallization and recrystallization, by R. S. Tipson, give very useful surveys of the literature and contain European as well as American references.

The binding conforms to that of the earlier volumes, and, while the price may deter individuals from purchasing this work, yet the book will probably find a place in most scientific libraries. E. F. G. H.

Ore Genesis

A Metallurgical Interpretation; an Alternative to the Hydrothermal Theory. By Dr. John Stafford Brown. Pp. 204. (London: Thomas Murby and Co., 1950.) 12s. 6d. net.

IN this stimulating book, first published in the United States, a serious challenge is offered to the established hypothesis that most sulphide ore deposits were precipitated from aqueous solutions, the last residues of consolidating magmas. Dr. J. S. Brown argues that the agreed facts of paragenetic order among sulphides could be explained were the minerals derived from an anhydrous sulphide magma, stratified like the immiscible layers in a non-ferrous smelting furnace (from top to bottom: slag, matte, speiss, galena-lead). Gaseous transfer is postulated, aided by water only at epithermal levels. The sulphide magma is pictured as a global layer beneath the basaltic shell, formed during primeval differentiation by separation of immiscible liquids, settled upon the top of an already-crystalline peridotite substratum. The primary oxide ores are considered to come from magma-pockets higher in the sima. To the end-stages of granitic plutonism are ascribed only the pegmatites. Gangue minerals—boron, fluorine and barium minerals excepted—come from the country rocks.

The physical data presented reveal the need for investigation of the vapour phases of the sulphides and oxides under high pressure. The idea of hypothermal and even mesothermal mineralization by vapours will be more favourably received in Great Britain than in Dr. Brown's own country, for the British have not abandoned their belief in pneumatolysis; indeed, some British petrologists ascribe far greater importance to diffusing fluids than is here implied. That the peridotite substratum was crystalline before the sial and basalt layers is harder to reconcile with current views on the primordial earth.

K. C. Dunham

Practical Physics

A Collection of Experiments for Upper Forms of Schools and Colleges together with the Relevant Theory. By Sir Cyril Ashford. Pp. xii+175. (Cambridge: At the University Press, 1950.) 10s. 6d.

FOR most of this collection of experiments for upper forms of schools and colleges, the author has used problems set during the past fifteen years in the higher school certificate papers of the Cambridge University Local Examinations Syndicate, and has transformed and amplified them to fit into a teaching course. Although the fifty experiments included deal with all branches of physics with the exception of sound, the book is not adequate for a normal two-year course such as is usually carried out in schools, nor is it suitable for this purpose. Its greatest value would be to the more brilliant and scholarship pupils in their last year at school, for they would undoubtedly derive great benefit by performing the experiments and following the excellent treatment of results given by the author.

The student is invited, not merely to do the experiment for the sake of practice in experimenting, but to act more as a pioneer who obtains results and then analyses them exhaustively; the writer thinks this is the right course to adopt. A very valuable introduction is provided dealing with the reduction of observations, and stress is laid on graphical methods with particular emphasis on linear equations. Altogether this is an excellent book which should be in the hands of all teachers of physics.

Principles of Human Geography

By P. Vidal de la Blache. Edited by Emmanuel de Martonne. Translated from the French by Dr. Millicent Todd Bingham. (Reprint.) Pp. xv+511+6 plates. (London: Constable and Co., Ltd., 1950.) 20s. net.

PROF. P. VIDAL DE LA BLACHE died in 1918, several years before this book was originally published. The translation first appeared in 1926, and the present volume is a reprint of that book. It says much for an unfinished book that it can bear unaltered reprint twenty-four years after its original appearance. But no other book on human geography has quite the standing of this volume, with the author's width of knowledge and wealth of examples of his principles. In the original manuscript, Prof. E. de Martonne had to correct minor mistakes and smooth out confused statements. But this could be done, and, despite a few obsolete statements and doubtful facts, the book is homogeneous and reliable. Prof. Vidal de la Blache surveys the world from a historical and evolutionary point of view. At times he is assertive; but he is always vivid and illuminating. Towards the end the book is fragmentary and all the more suggestive to the serious student. There are several maps showing various distributions. It is a book free from jargon and one that the general reader can easily follow, while no serious student of geography can afford to neglect it. R. N. R. B.

SCIENTIFIC CENTENARIES IN 1951

By Engineer-Captain EDGAR C. SMITH, O.B.E., R.N.

AMONG the centenaries of 1951, that of the Great Exhibition of 1851 will in Great Britain overshadow all others in general interest. Unlike the Festival of Britain, the Exhibition had little backing from the Government of the day, and it was Mr. (afterward Sir) Henry Cole who remarked that "a great part of the success which has attended the institution of this Exhibition may be attributed to its independence of the Government; and it may be the boast of our countrymen, that the Exhibition was originated, conducted and completed independently of any Government aid whatever, except its sanction . . .". The Queen, it is true, appointed a Royal Commission "to make full and diligent inquiry", but no Government department was represented on it as such. Many men of science and engineers were, however, on the Commission, these including the Earl of Rosse, president of the Royal Society, Sir Charles Lyell, president of the Geological Society, and William Cubitt, president of the Institution of Civil Engineers. Scott Russell, the shipbuilder, was one of the secretaries of the Commission, and Robert Stephenson was appointed chairman of the Executive Committee.

There were many critics of Paxton's famous building for the Exhibition, and when its design was discussed at the Institution of Civil Engineers, Airy, the Astronomer Royal, as he wrote, "expressed himself strongly on the faulty principles of its construction". Criticisms came from many quarters. Some people said that it would fall from sheer weight or from vibration, others that the heat of the sun would cause the iron columns to be pushed out of line, while others thought that gales would blow it down. Destruction of the glass, it was feared, would come through the firing of cannon in Hyde Park or through the playing of orchestras and the organ. Yet another criticism was that a hailstorm would leave the whole of the roof without glass. As is well known, none of these things happened, and the Crystal Palace, on its later site at Sydenham, finally came to its end in 1936 through fire.

As time passed, many other men of science besides those already mentioned became connected with the Exhibition in one way or another, one of the most active being Mr. Lyon (afterwards Lord) Playfair, and various interesting sidelights on the Exhibition and the scientific world can be obtained from the memoirs of Playfair and others. Included in the long list of jurors was Sir David Brewster, who was greatly interested in the Kohinoor diamond. This famous gem, when exhibited, at first caused disappointment; but at Brewster's suggestion "fifteen or sixteen gas lights were placed behind it", when it "threw out a radiance of coloured light which delighted all who saw it". One day Brewster made the acquaintance of Charlotte Brontë, "a pleasing little woman about forty, modest and agreeable", and he accompanied her through the Exhibition. The work of a juror did not, however, exhaust all Brewster's energies, for on July 22 he presided over and addressed a Congress of Peace in the once famous Exeter Hall, which stood where the Strand Palace Hotel, London, is now.

One of the most vivid chroniclers of the time was the geologist Sir Andrew Ramsay. In January 1851, there was a jovial dinner of the Royal Hammerers at which Sir Henry De la Beche, Edward Forbes, Warington Smyth, James Forbes, Playfair and others were present. When Ramsay and Forbes joined in, the fun was fast and furious. A bit later there was the anniversary dinner of the Geological Society, at which "Sedgwick made the great speech of the evening. By turns he made us cry and roar with laughter as he willed." Then the "Red Lions", some of whom had monthly meetings in London, got mixed up with a dinner to the Press of all nations, for which half an ox was roasted in the garden and then carried in by twelve cooks, the band playing "The Roast Beef of Old England". In sterner mood, Ramsay recorded the opening on March 12, by the Prince Consort, of the School of Mines and Museum of Practical Geology, in Jermyn Street, London. De la Beche was president of this institution, and the staff consisted of Playfair, Edward Forbes, Robert Hunt, John Percy, Ramsay and Smyth.

In those days, at Cambridge, Stokes was Lucasian professor, Challis was Plumian professor, Peacock was Lowndean professor, as well as Dean of Ely, while Sedgwick was Woodwardian professor. As Master of Trinity, Whewell had already attained that dominating position in the University which led someone to write:

> "You may roam where you will through the realms of infinity
> And meet nothing so great as the Master of Trinity".

Science at Oxford was still somewhat in the doldrums, but among men of distinction there were Baden Powell, Savilian professor of geometry, W. F. Donkin, Savilian professor of astronomy, Daubeny, professor of chemistry, while Buckland was reader in geology and also Dean of Westminster, a position he held from 1845 until 1856. Under him the Deanery became a meeting-place for literary and scientific men and engineers, Liebig being among his visitors in 1851. During the Great Exhibition, the Dean's son, Frank, then a medical student, with two companions climbed to the roof of the nave of Westminster Abbey and hung therefrom a Foucault pendulum. It was suspended just opposite the door to the Deanery and swung over a dial on the pavement.

The Royal Society at that time was still housed in Somerset House, and it was there in 1851 that Owen received the Copley Medal and Faraday read one of his papers on the lines of magnetic force, a subject which he said "has at different times been greatly influential in leading me to various results which I think prove their utility as well as fertility". Close to Somerset House, in King's College, Wheatstone, as professor of experimental philosophy, was adding to his reputation though doing little lecturing; in Oxford Street, the Royal College of Chemistry was under the guidance of the great Hofmann, while the University of London saw the labours of such as Thomas Graham and Augustus de Morgan. Connected with the various institutions were Sir John Herschel, then Master of the Mint, Darwin, who had been settled at Down, Kent, for nine years, and two young medical men, Huxley, who at the age of

twenty-five had not long returned from his long commission in H.M.S. *Rattlesnake*, and Lister, his junior by two years, who was still a London student. But none of these was more interested in the Exhibition and its wealth of manufactures and machinery than Babbage. He had been disappointed at not being placed on the Royal Commission, and still more disappointed that his famous calculating machine—then Government property—was not on show; but he had his compensations, and records that: "I frequently accompanied the Duke of Wellington to the Exhibition or met him there by appointment at the Crystal fountain". To Babbage was due the volume, "The Exposition of 1851; or Views on the Industry, the Science and the Government of England".

There had been many Expositions, especially in France, before 1851, but none with such a wide scope and none planned with such high hopes. At a banquet at the Mansion House, London, on March 20, 1850, the Prince Consort, referring to the coming Exhibition, said: "nobody, however, who has paid any attention to the particular features of our present era, will doubt for a moment that we are living at a period of most wonderful transitions, which tends rapidly to accomplish that great end—to which indeed all history points—the realization of the unity of mankind. . . . The distances which separated the different nations and parts of the globe are gradually vanishing before the achievements of modern invention and we can traverse them with incredible speed; the languages of all nations are known . . . thought is communicated with the rapidity, and even by the power, of lightning. On the other hand, the great principle of the division of labour, which may be called the moving power of civilization, is being extended to all branches of science, industry and art. . . ." Journals and periodicals all joined in the chorus of approval, and when the Exhibition was open, vied with each other in their laudatory reviews. "What has antiquity to show," said the *Athenæum*, "in comparison with the scene in Hyde Park? The noblest congresses of the ancient world look narrow, insular and local by its side. . . . The Crystal Palace knows no difference between Jew and Greek, Frank and Saxon. In that arena for the first time in the annals of mankind, the Negro, the Malay, the Sclave and the American, will stand together on equal terms; and merit, of its kind, will carry away the honours of genius and industry, without reference to questions of blood, type or colour. This is a starting-point for the true theory of the equality of nations—a new era in the history of progress."

Though the Exhibition contained wonderful displays of the manufactures, merchandise and raw materials of the whole world, it was, above all, a demonstration of what science, invention and engineering had achieved. Among the thirty classes of objects were those devoted to railways, locomotives, steam engines, ships, machine tools, textile and agricultural machinery, chemical processes and the like. There were models of bridges by Stephenson, Brunel and Vignoles, Nasmyth's steam hammers, Armstrong's hydraulic hoists, Appold's centrifugal pumps, Whitworth's lathes, Fairbairn's riveting machines, Applegarth's printing machines, McCormick's reaping machine, Snow Harris's lightning conductor for ships, a steel gun from Krupp's, models of the Bell Rock and Skerryvore lighthouses—an almost endless variety of objects. One class was devoted to "Philosophical Instruments", and here the list of exhibitors included the names of Ross, Dollond, Ericsson, Bourdon, Froment, Oertling, Siemens, Merz, Ertel, De la Rue and Negretti and Zambra. Electric clocks gave the time throughout the building, in which were several telegraph stations "at which boys worked Cooke's Needle Telegraph, sending messages—not too long—to various parts of London, for the charge of 1*s*.".

The Exhibition was formally opened on May 1 by Queen Victoria and was officially closed on October 15, the final event being the singing of the Hallelujah Chorus. There was no admittance on Sundays, and the charges for entrance were 1*s*. for the first four days of each week, 2*s*. 6*d*. on Fridays and 5*s*. on Saturdays, the last being reduced to 2*s*. 6*d*. from August onwards. At times there were as many as 90,000 persons in the building. More than £350,000 was taken at the doors, and one small item of revenue was £7 14*s*. 11*d*. for weather charts. About a quarter of a million copies of the official catalogues were sold, which, said the *Edinburgh Review*, if piled in a vertical column on the bed of the Pacific Ocean, would rise above sea-level and "form a lonely peak rising to the height of Chimborazo or Cotopaxi". Fortunately, the Exhibition made a handsome profit, a part of which was used to purchase the market gardens to the south of Hyde Park, a tract of land now partly covered by some national museums which will play a part in the Festival of Britain.

Turning from the centenary of the great event of 1851 for Great Britain to the centenaries and bi-centenaries of men of science, invention and engineering which occur in 1951, the first list includes the honoured names of Oliver Lodge, George Frederick Fitzgerald, Arthur Schuster, George Chrystal, Silvanus Thompson and Francis Maitland Balfour, who were all born in 1851. There is no need to refer here in detail to their attainments and achievements. They all left their marks on the progress of science and stimulated both their contemporaries and successors. The career of Sir Oliver Lodge was bound up with the fortunes of the Universities of Liverpool and Birmingham, that of Fitzgerald with Trinity College, Dublin, that of Sir Arthur Schuster with the University of Manchester, that of Chrystal with the University of Edinburgh, that of Balfour with Cambridge and that of Silvanus Thompson with Finsbury Technical College, of which he was professor of physics and principal from 1885 until 1916.

The advantages of being brought into contact at an early age with men of character and distinction has often been remarked on, and no one could listen to Silvanus Thompson without carrying away indelible impressions of an eloquent, skilful and lucid lecturer. His many scientific papers, his addresses, his treatises on electricity and magnetism and his linguistic attainments made his name known throughout the scientific world, and not the least of his contributions to science were his biographies of Faraday and Kelvin. Sir Oliver Lodge died in 1940 at the age of eighty-nine, Sir Arthur Schuster in 1934 at eighty-three, Thompson in 1916 at sixty-four, Chrystal in 1911 at sixty; but Fitzgerald lived only to the age of forty-nine. Francis Maitland Balfour died when but thirty. At Cambridge, however, he had already founded an active school of zoologists, and in the spring of 1882 a special professorship of animal morphology was instituted for him. A few months later, while on holiday, on July 19, he lost his life attempting to climb one of the spurs of Mont Blanc.

The losses to science in 1851 were many and widespread. German astronomy was the poorer by the death of Ludwig von Boguslawski, director of Breslau Observatory and known for his many observations of Bode's, Biela's, Encke's and Halley's comets, and German mathematics by the death at the age of forty-six of Karl Gustaf Jacob Jacobi, of Königsburg and Berlin. Ball said of Jacobi that "he was the greatest mathematical teacher of his generation . . . and influenced the more able of his pupils to an extent almost unprecedented at that time". French science lost the service of Baron Buquoy, known for his researches in physical science and his many experiments on glass; and Louis-Jacques-Maudé Daguerre, the painter of dioramas and the pioneer of photography, who collaborated with both Nicéphone and Isidore Niepce. On March 9, 1851, the eminent Danish electrician, Hans Christian Oersted, died at Copenhagen at the age of seventy-three, thirty-two years after he had published his paper, "Experiments on the Effect of Opposing Electricity upon the Magnetic Needle", which gained for him the Copley Medal of the Royal Society and many other honours. In 1846, Oersted had attended the Southampton meeting of the British Association, and Playfair, who met him there, wrote: "Oersted was a man of peculiar fascination, being a poet as well as a philosopher. He was forty-two years older than myself, but we formed a warm friendship and he corresponded with me during the few remaining years of his life."

Among the British men of science who died in 1851 were William Nicol, who, leading a retired life in Edinburgh, devoted himself to microscopic studies of fossil woods and crystals and whose name is recalled by the 'Nicol' prisms; John Kidd, the son of a sea captain who became the first Aldrichian professor of chemistry at Oxford, and who in the dark chambers beneath the Ashmolean Museum gave voluntary lectures on geology which were attended by Daubeny, the Conybeares and Buckland, and Richard Cowling Taylor, another student of geology, who came under the influence of William Smith, and, after acting as a land surveyor, in 1830 emigrated to the United States, where he did good work in exploring the iron- and coal-fields of Pennsylvania. To this tale of losses must be added the name of Richard Phillips, the Quaker friend of Luke Howard and William Allen, lecturer in chemistry at the London Hospital and the Royal Military Academy, Sandhurst, editor for many years of the *Philosophical Magazine*, president of the Chemical Society and chemist to the old Museum of Economic Geology. He died the day before the new Museum was opened, and Ramsay wrote: "A terrible damper occurred which was kept from Sir H. Faraday told Hunt just before the Prince came that poor old Richard Phillips had died yesterday. It was a shock to me. Strange that he should have died at the opening of the Museum. I feel myself unconsciously repeating his jokes. . . ."

The record of births and deaths in 1751 brings to mind the fruitful career of the French mineralogist, Jacques-Louis Count de Bournon, who was born at Metz on January 21, 1751, and died at Versailles on August 24, 1825, while in charge of the cabinet formed by Louis XVIII. His earlier years were spent as an officer in the artillery, but at the Revolution he came to England, where his services were much appreciated in geological circles. In the story of the Geological Society it is stated that "Count de Bournon had written an elaborate monograph on carbonate of lime, and in order to raise funds for its publication Dr. Babington invited to his house a number of gentlemen distinguished by their zeal in mineralogical knowledge, when a subscription list was opened and the necessary sum was collected. Other meetings of the same gentlemen took place for friendly intercourse, and it was then proposed to form a geological society. On November 13, 1807, a meeting was held at the Freemason's Tavern, Great Queen Street, at which resolutions were passed formally constituting the Society." Only eleven were then present, but among these were William Babington, M.D., F.R.S., and Count Bournon, F.R.S. After the restoration of the French monarchy, the latter returned to his native country.

Another Frenchman of note, but one who served in the infantry, was Claude-François-Dorothée, Marquis de Jouffroy d'Abbans, who at the age of twenty-five, in 1776, attempted to drive a boat by steam on the River Doub. In 1783 he made another experiment on the Saône at Lyons, but he too had to emigrate and was absent from France for ten years or so. He died a pensioner in the Invalides on August 7, 1832. A statue of him was set up at Besançon in 1884, and in 1933 a tablet to him was dedicated in the fortress of Ste. Marguerite near Cannes, where he was once interned. Far more peaceful were the careers of the English mathematicians Isaac Milner (1751–1820) and Abraham Robertson (1751–1826). Both came of humble parentage, both became schoolmasters and clergymen, but while Milner held the Cambridge posts of professor of natural philosophy, president of Queens' College and Lucasian professor, Robertson was during 1797–1810 Savilian professor of geometry and from 1810 until his death Savilian professor of astronomy at Oxford.

Of the several notable men of science who died in 1751, Benjamin Robins and George Graham, like Silvanus Thompson and Richard Phillips, were sons of Quakers, and Graham remained a Quaker all his life. Robins was born in Bath in 1707, and Graham in Cumberland in 1673; but whereas Robins became a mathematical tutor, a civil engineer, a political pamphleteer, the editor of Anson's "Voyages" and finally the engineer-in-chief of the East India Company, Graham learnt the trade of a clockmaker under the famous Tompion, married Tompion's niece, succeeded to Tompion's business in Fleet Street, London, and in November 1751 was buried in the grave of Tompion in the nave of Westminster Abbey. Robins is to-day remembered as the inventor of the ballistic pendulum and the author of the "New Principles of Gunnery" (1742), while Graham is remembered for his invention of the mercurial pendulum and the dead-beat escapement, and for the many notable astronomical instruments he constructed for Halley, Bradley and others.

To another branch of science belongs the name of Andrew Gordon (1712–51), who was born in Angus, Scotland. He was sent to Germany at the age of thirteen and became a Benedictine monk and held the chair of philosophy in the University of Erfurt. He too gained a European reputation and was made a *correspondant* of the Paris Academy of Sciences. He made experiments and wrote works on electricity, and was the first to devise an electrical machine with a cylinder instead of a globe. Contemporary with these famous men was the long-lived "Kristofer Polhammer, ennobled Polhem. The Archimedes of

the North, 1661–1751", of whom an account was given to the Newcomen Society in 1926 by Mr. J. G. A. Rhodin. Mining and minerals and smelting, handling plant and locks and docks were all improved by the work of Polhem, whom Charles of Sweden made 'Assessor' to his Board of Trade. His "Patriotic Testament" was written when he was eighty-five, but was not published until ten years after his death.

Finally, to bring this review to a close, mention may be made of Flamsteed's friend, assistant and collaborator, the Yorkshireman Abraham Sharp. Born three hundred years ago at Little Horton, near Bradford, Sharp was apprenticed to a merchant at Manchester; but he became a schoolmaster at Liverpool, and it was there that Flamsteed met him. He constructed a mural quadrant which, like the instruments of Graham, Bird and Troughton, is preserved at Greenwich, and Smeaton once wrote of him: "I look upon Mr. Sharp as having been the first person that cut accurate and delicate divisions upon astronomical instruments". The latter part of Sharp's life was spent at his birthplace, where he died on July 15, 1742, at the age of ninety-one.

There are, of course, other individuals who might have been added to this sketch if space permitted. Such were the German physicist, E. W. von Tschirnhausen (1651–1708), the French chemist, J. F. Clouet (1751–1801), the French-American ornithologist, J. J. Audubon (1780–1851), the United States Army surgeon, W. Reed (1851–1903) and Sir John Jackson (1851–1919), the constructor of great civil engineering works. They had at least this in common, that they believed with Lord Kelvin that:

"To know, to do, and on the tide of time
Not to drift idly like the cockle sailor,
Whose pearly shallop dances on the blue,
Fanned by soft airs, and basking in brief sun;
But to steer onward to some purposed haven
And make new waves with motion of our own,
That is to live".

GEOLOGICAL SURVEY OF INDIA

CENTENARY CELEBRATIONS

By Sir LEWIS FERMOR, O.B.E., F.R.S.

PRIOR to the formation of the Geological Survey of India as an official Department, a considerable amount of geological investigation was carried out in India by amateurs in the service of the East India Company, principally surgeons, officers of the Trigonometrical Survey, and civil administrators. The work of three of these pioneers has proved to be of enduring value, namely, that of Captain Newbold, F.R.S., on the geology of southern India, and the joint researches of Dr. H. Falconer, F.R.S., and Sir Proby Cautley, F.R.S., on the fossil vertebrate fauna of the Siwalik Hills. Four of these early investigators received official appointments for geological work, namely, Laidlaw (mineralogist to the Survey of Kumaon, 1817–21), Dr. H. W. Voysey (geologist to the Great Trigonometrical Survey, 1818–23), Captain Dangerfield (Malwa and the Geological Survey of the Himalaya Mountains, 1820–22), and Captain J. D. Herbert (geological surveyor of the Himalaya Mountains, 1823–29). Voysey is sometimes called the 'father' of Indian geology.

The appointment, in 1846, by the Court of Directors of the East India Company, on a recommendation originating from the Committee for the Investigation of the Coal and Mineral Resources of India, of D. H. Williams as "Geological Surveyor to the East India Company" has already been discussed at length in an article by Sir Cyril Fox (*Nature*, **160**, 889; 1947). When Williams died in 1848, Dr. John McClelland, secretary of the Coal Committee, deputized until 1850, and, after an interval, a successor, Dr. Thomas Oldham, was appointed in 1851. About this time a rival Punjab Geological Survey was begun under Dr. A. Fleming for the purpose of surveying the Salt Range; this Survey lasted from March 1848 until September 1852.

In attempting to decide whether to date the Geological Survey of India from Williams's arrival in 1846 or Oldham's in 1851, it is necessary to remember that Williams's survey was a one-man effort, and that he nowhere uses the term Geological Survey of India, nor is this term used in official correspondence with reference to his work. McClelland has confused the issue slightly by his use of this term; but it appears to have been an unofficial use, and to represent what had all along been McClelland's objective; for it must be remembered that it is mainly to his efforts as secretary to the Coal Committee that the directors of the East India Company were induced to appoint a geological surveyor. Although Oldham also bore the same title as Williams, namely, "Geological Surveyor to the East India Company", nevertheless he at once started describing himself as "Superintendent of the Geological Survey of India", and this term was also used in official correspondence. Moreover, he began immediately to recruit other geologists, J. G. Medlicott being appointed late in the same year 1851, R. I. St. George in 1852, H. B. Medlicott in 1854, and W. T. and H. F. Blanford in 1855. Also, in 1853, William Theobald, who had been working with the Punjab Geological Survey until that organization ceased to function, and who had become a useful geologist, applied to Oldham for a post in the Geological Survey of India and was accepted on the basis of a new appointment in a new department.

In consideration of all the interlocking and somewhat confusing data, it has been decided to treat the period 1846–51 as a preliminary one and to regard the continuous Geological Survey of India as dating from 1851. It is this centenary that is being celebrated in Calcutta this month, though the actual centennial date will be March 5, 1851.

Thomas Oldham at the time of his appointment was thirty-five years of age and local director of the Geological Survey of Ireland and professor of geology in Dublin; he had been elected to the Royal Society at the early age of thirty-two. He was appointed on a five-year agreement, and his office was renewed in five-year spells until he retired in 1876 after twenty-five years of service. Oldham must, therefore, be regarded as the architect of the Geological Survey of India. During this period he succeeded in having the strength of the Department raised to sixteen; and, in spite of a very high death-rate in the early days, an amazing amount of good work was accomplished and large tracts of India surveyed on a broad scale. The early geologists included the two brothers Medlicott and the two brothers Blanford, of whom the younger, H. F., left the Department early and became the first meteorological reporter to the Government of India. Other well-known men appointed to the Survey during Oldham's time included William King, Bruce Foote, F. R. Mallet, Theodore Hughes, A. B. Wynne, Valentine Ball, and

the palæontologists Waagen, Stoliczka, Lydekker and Feistmantel.

During these twenty-five years the foundations were laid of our knowledge of Indian stratigraphy, and such famous terms were introduced as Aravalli, Cuddapah, Vindhyan, Gondwana, and some of the principal Himalayan systematic names. The Talchir boulder bed was recognized (by W. T. Blanford) as of glacial origin and the germ of the idea of Gondwanaland thereby created. H. B. Medlicott made his classic study of the sub-Himalayan ranges of the Punjab, and Wynne his equally classic study of the Salt Range, in which, confirming Fleming's survey, he showed that the Saline Series, underlying Palæozoic beds, is the oldest series exposed in the Salt Range, and of quite different age from the Tertiary Kohat salt, a result that has not been upset in spite of recent micro-palæobotanical research.

On the economic side the chief attention was given to the survey of the Indian coalfields, mainly by W. T. Blanford, Hughes and Ball, Hughes being the most prominent in this. Oldham also initiated the scientific study of earthquakes in India and prepared catalogues both of past earthquakes and of the hot springs of India. He published the first Indian mineral statistics.

During this period also was built the present Indian Museum, to which the Department was transferred with its collections, from its earlier home in Hastings Street, Calcutta, just before Oldham retired. The collections in the Museum were obtained partly by purchase, exchange and gift, and partly by the Survey's officers in the field. The Greg collection of meteorites, obtained by purchase, was one of the most notable of these additions to the Museum; with the frequent receipt of the stony meteorites that are seen to fall in India, the Calcutta collection remains one of the best in the world.

Passing from the early days of survey, reference must now be made to the remaining seventy-five years of the departmental history. H. B. Medlicott, on succeeding Oldham, proceeded at once to carry out the latter's project for a "Manual of the Geology of India" to summarize the results of the work of this initial period of the Department's work. The first two parts of this Manual, written by Medlicott and W. T. Blanford in collaboration, were published in 1879, with the first authentic geological map of India (first edition issued in 1877). Part 3, on "Economic Geology", by Valentine Ball, was published in 1881, and Part 4 on "Mineralogy" by Mallet, in 1887, who had arranged the mineral collections of the Department and who must be regarded as the 'father' of Indian mineralogy.

The results achieved during Oldham's period as superintendent had been achieved without the use of the microscope in the study of rocks, so that no serious studies had been made of the detailed constitution of the metamorphic gneisses and schists of the Peninsula. The introduction of the use of the microscope for petrology in India was due to General McMahon, during Medlicott's time. During the same period Bruce Foote, working in southern India, distinguished belts of schists from the associated gneisses under the term 'Dharwar'.

In 1885 the title of the head of the Department was changed from superintendent to director, and the term superintendent was applied to the officers in charge of the main subdivisions of work under the director. Medlicott retired in 1887, and was succeeded in turn by William King (1887-94) and C. L. Griesbach (1894–1903). Under these two directors work continued on the lines already laid down. But on the promotion of T. H. Holland to be director in succession to Griesbach, new vigour was imparted to the Department. The number of personnel was increased, the emoluments of the officers improved, increased importance was given to economic studies, and special memoirs were issued on coal, manganese ore and petroleum. Holland also revived the dormant *Records of the Geological Survey of India*, and started the publication therein of reviews of the mineral production of India, both annual and quinquennial. In order to encourage investigation where private enterprise lagged, Holland secured a grant for the purpose of drilling on the copper belt of Singhbhum, and the present successful Indian Copper Corporation must be regarded as a lineal successor of the work then undertaken. The effect of Sir Thomas Holland's appointment as director can be compared to that of a geological uplift fault, for the Department was raised by him in both public and government esteem to an altitude it had not previously occupied, and from which it has not fallen back.

Since Holland's time, successive directors have been Sir Henry Hayden (1910–21), Sir Edwin Pascoe (1921–32), Sir Lewis Fermor (1932–35), Dr. A. M. Heron (1935–39), Sir Cyril Fox (1939–43), Dr. E. L. G. Clegg (1943–44) and Dr. W. D. West (1945-).

Hayden's period covered the First World War, at the outbreak of which he encouraged as many officers as possible to join the Armed Forces. Eight officers took advantage of this sanction and obtained commissions, and one of the most promising of the young men, R. C. Burton, lost his life in Mesopotamia. Of the others who went on active service to various parts of the world, six were recalled before the end of the War because of the need to promote the production of minerals in India, of which mica and wolfram were the most important; the Department took charge of the production of mica from certain parts of Bihar, and helped to promote the output of wolfram from Tavoy in Burma.

Pascoe's period was marked by the institution of a re-survey of Indian coalfields, and also of the Salt Range, the latter for the purpose of settling by mapping revived controversy on the age of the Saline Series. Under Pascoe the Department reached the increased strength for which sanction had been obtained by Sir Henry Hayden.

My own period as director (which really commenced with Pascoe's departure on leave in 1930) was unfortunate because it coincided with the world-wide depression of 1931–32 and the decision of the Government of India to retrench severely all its scientific services. In the end, after much resistance, the blow was softened, but nevertheless the departmental strength was reduced by various devices from thirty to twenty graded officers. My period was also characterized by the occurrence of several great earthquakes in India and Burma, of which the most disastrous were those of Bihar (January 15, 1934) and Quetta (May 31, 1935), each accompanied by great loss of life. Such earthquakes also affect the field-work of the Department, as it is the practice to send officers immediately into the field to study the affected areas.

Dr. Heron succeeded in retrieving some of the lost posts, a process continued by his successor, Sir Cyril Fox. Fox had also to cope with the incidence of the Second World War and the need to stimulate the production of minerals in India, and as a result of

these needs he formed a minerals utilization branch of the Department. He also found it necessary, partly because of the shortage of paper, to suspend the normal publications of the Department.

Dr. Clegg died unexpectedly after a very short spell of office, so that to Dr. West has fallen the task of the complete reorganization of the Survey in view of the need to recruit a great number of young Indian geologists to provide for a great expansion of departmental activities.

During Oldham's time there was no provision in India for geological education, and consequently it was impossible to obtain qualified Indians for the staff. Accordingly, Oldham introduced a system of apprenticeship, but this was not a great success. The first Indian to be appointed after geological education abroad was P. N. Bose (1880), followed by P. N. Dutta (1888); but the Indianization of the Department did not make much progress until the present century, when increasing provision for geological education in India, and increased facilities in the form of scholarships for study abroad, ensured a steady supply of well-trained Indian geologists. The position now is that there are only two Europeans left on the graded staff, with a few such officers on short-term agreements for special purposes. The training of the numerous young Indian geologists who have been recruited at a great pace recently has proved a problem, partly solved by sending a batch to the University of Melbourne for training, and partly by the institution of geological survey training camps in India.

The well-known publications of the Department, namely, the *Memoirs* and the *Records of the Geological Survey of India* and the *Palæontologia Indica*, the latter containing descriptions of the fossils, faunas and floras of India contributed by specialists in the various groups all over the world, were all started by Thomas Oldham. There have unfortunately been two breaks in the continuity of the *Records*, the first during Griesbach's directorship, when he apparently found too troublesome the regular issue of this publication, intended to be quarterly, and instead issued a director's annual report. The other break was during the Second World War, when paper was difficult to obtain. An additional journal, entitled *Indian Minerals*, has been added to the departmental publications since 1947; this is issued for the purpose of disseminating information on economic problems and is of a semi-popular nature.

The first edition of the "Manual of the Geology of India", Parts 1 and 2, by Medlicott and Blanford, was, as already mentioned, issued in 1879, and this work was revised in one volume by R. D. Oldham (the son of Thomas) in 1893. Sir Edwin Pascoe undertook the preparation of a new edition during his retirement, and a portion of this was in the press and ready for printing off when the Second World War broke out. The paper shortage prevented its issue, and eventually the type-metal, being needed for other purposes, was melted down. After the War the work had to be reset and modified in view of the number of years that had elapsed. But Sir Edwin Pascoe, before his recent untimely death, succeeded in passing the proofs of the first volume, and I understand that this has now been issued, though no copies appear yet to have reached Great Britain. We may regard as a preliminary to this latest edition of the Manual the latest (fifth) edition of the "Geological Map of India and Adjacent Countries" on the scale of 1 inch to 32 miles, issued in eight sheets in 1928. Mention must also be made of the most useful of all recent Indian geological publications, T. H. D. La Touche's wonderful "Bibliography of Indian Geology and Physical Geography with an Annotated Index of Minerals of Economic Value", published in four parts during 1917–26.

One other important point requires mention, namely, the changes in the geographical scope of the Geological Survey of India. Up to 1937 the Department was responsible for the geological survey of both India and Burma, but on April 1, 1937, Burma was separated from India, and the new Burma Geological Department was formed, staffed by officers seconded from India. The partition of the Indian Empire on August 15, 1947, necessitated the formation of a Geological Survey of Pakistan, of which Dr. H. Crookshank, then due shortly to retire from the Indian Survey, became the first director, while Dr. W. D. West continued as director of the Geological Survey of India.

Throughout its history the Geological Survey of India has not, however, restricted its scope to the political boundaries of India and Burma. Instead, opportunities have been taken of deputing officers to accompany military and other expeditions, including boundary commissions, so that the Department has contributed largely to our knowledge of the surrounding countries—for example, Blanford in Persia and Abyssinia, Pilgrim in Persia, Mallet in Aden, Griesbach and Hayden in Afghanistan, Stoliczka in Yarkand, Hayden and Heron in Tibet, and Coggin Brown in Yunnan—which explains the words "and Adjacent Countries" in the title of the geological map of India already mentioned.

THE STATISTICAL THEORY OF SOLUTIONS

A CONFERENCE on "The Statistical Theory of Solutions" was held in the Department of Chemistry, University of Manchester, during the week-end September 30–October 2. The central topic of discussion was the molecular interpretation of free energies of mixing and the other bulk thermodynamic properties of solutions. The interpretation and correlation of these properties is of obvious importance in connexion with phase equilibria, and various speakers showed how statistical theory could be applied to transitions in the solid state, liquid–vapour equilibria in the critical region, and the virial coefficients of mixed gases.

The first meeting, at which Prof. M. G. Evans presided, was opened by Prof. E. A. Guggenheim (Reading). He began with a historical survey of the theory of regular solutions, as developed by Fowler and his school, and went on to describe some new work being carried out at Reading by Mr. M. L. McGlashan. Leaving aside the question how well the assumptions of the theory describe real solutions, there are two essentially distinct mathematical methods by which it is possible to calculate the free energy of a quasi-crystalline solution. The first method is to expand the free energy of mixing as a power series in w/kT, where $w = 2w_{AB} - w_{AA} - w_{BB}$, and w_{AB} is the (free) energy of an AB contact; this method was later discussed in more detail by Dr. G. S. Rushbrooke. The second is the combinatory method, or its equivalent, the quasi-chemical method.

In this approximation the sites in the pseudo-lattice are considered in pairs, sets of three, or larger groups, and it is assumed that the modes of occupation of these different groups are independent of one another. This assumption will become more accurate the larger the number of sites in a group; and Prof. Guggenheim compared the results of the so-called 'zeroth' approximation with those of the combinatory method applied to pairs, triangles and tetrahedra of sites on a close-packed lattice. The zeroth approximation is surprisingly good, but there should be a definite trend in the calculated free energy as successively larger groups of sites are considered. Mr. McGlashan reported some interesting calculations on the alloy Cu_3Au, where a transition predicted by the zeroth approximation disappears in the first two combinatorial approximations, but reappears when sets of four adjacent sites are considered.

A short account of the method of power series expansion was given by Dr. G. S. Rushbrooke (Oxford). He outlined how it is possible to expand the restrictive grand partition function as a power series in w/kT at high temperatures, or in $\exp(-w/kT)$ at low temperatures. It has not been possible to establish rigorously that either series converges; but numerical computations made by Mr. A. J. Wakefield for the case of equal activities strongly suggest that the regions of convergence of the two expansions meet at the critical mixing temperature, which is given approximately by $w/kT_c = 0{\cdot}45$. It seems that, in the absence of an exact solution to the three-dimensional lattice problem, the method of power series expansion will probably give the most reliable information available as to the free energy of a quasi-crystalline solution.

Prof. Evans then asked whether it was possible to make any useful statement as to the dependence of the parameter w upon temperature or pressure, since this dependence would have an important effect upon the excess entropy or volume of mixing. In reply, Prof. Guggenheim said that w is not to be regarded as an ordinary absolute energy; it is defined in terms of the work required to interchange an interior molecule of liquid A with an interior molecule of liquid B, and can only be obtained statistically by averaging over all accessible states of the remainder of the system, weighting each state with the appropriate exact Boltzmann factor. For this reason w may be described as a 'co-operative free energy', and would be expected to vary with temperature, though not with composition. Prof. Guggenheim stressed the point that for regular solutions the temperature-dependence of w does not affect calculations of the free energy, which are based on strictly isothermal arguments; but it is not possible to calculate entropies and volumes of mixing without additional information as to how w varies with T and p. In the discussion that followed, in which Dr. Rushbrooke and Dr. Longuet-Higgins took part, attention was focused on the difficulty of even writing down the partition function if w is regarded as anything but an absolute energy; allowing w to vary with T makes the theory more elastic, but at the cost of introducing further uncertainties.

At the second session Dr. H. C. Longuet-Higgins (Manchester) described an alternative approach to the theory of solutions. Theories of solution are generally based on some definite or indefinite model of the liquid state, such as the Lennard-Jones cell model or the quasi-crystalline model, and it is difficult to be certain that such a model is statistically consistent with any particular assumptions about the intermolecular forces. However, it is possible to find a set of reasonable assumptions about these forces which enables one to calculate the thermodynamic properties of mixing without appealing to any model at all. It is assumed that, for every pair of molecular species r and s in the solution, the intermolecular energy u_{rs} as a function of distance ρ is given by the equation $u_{rs}(\rho) = f_{rs}u_{ss}(g_{rs}\rho)$, where $u_{ss}(\rho)$ is the intermolecular energy function of some chosen component, and f_{rs} and g_{rs} are constants close to unity. A system satisfying these assumptions may be called a 'conformal solution'; and it can be proved that for a binary conformal solution the excess free energy of mixing at constant T and p is given by the equation

$$\Delta^*G = E_s(2f_{12}-f_{11}-f_{22})x_1x_2,$$

plus terms of the second order in $(f_{rs}-1)$ and $(g_{rs}-1)$, where E_s is the intermolecular energy of the chosen component, and x_1 and x_2 are mole fractions. Now E_s is an observable quantity, the variation of which with temperature and pressure can be measured experimentally; so it is possible to correlate the excess free energy, entropy and volume of a conformal solution in terms of the experimental properties of the components; and these predicted correlations are in good agreement with available data on non-polar solutions. It is interesting to note that, even though the molecular distribution in a conformal solution is random in first approximation, there may nevertheless be a first-order excess entropy of mixing, connected with the temperature variation of E_s. The succeeding discussion, in which Mr. R. P. Bell (Oxford) and Prof. Guggenheim took part, returned to the interpretation of entropies of mixing; and it became clear that non-ideal entropies of mixing are not necessarily to be understood in terms of order and disorder.

The next speaker, Mr. D. Cook (Manchester), described the quantitative application of conformal solution theory to phase equilibria in the critical region and, in particular, to the system ethylene carbon dioxide, recently studied experimentally at the Imperial College of Science and Technology, London, by Mr. S. M. Shah and Prof. D. M. Newitt. In order to calculate the T, p, x curves for the two-phase region, it is necessary to calculate E_s from the equation of state of, say, carbon dioxide; this can be done by extrapolating the available p, V, T data to the requisite low temperatures, but it introduces an unavoidable uncertainty into the theoretical results. Nevertheless, using a value of $2f_{12}-f_{11}-f_{22}$ derived from the observed critical-temperature curve, one can calculate with considerable accuracy the compositions of phases in equilibrium at a given temperature and pressure; and, in particular, the theory predicts the observed azeotropy in this system, and the direction in which the azeotropic composition varies with temperature.

Mr. McGlashan and Prof. Guggenheim then explained a method of calculating the second virial coefficients of gaseous mixtures from the virial coefficients of the pure components known as functions of temperature. This method is based on similar assumptions to those of conformal solution theory, except that it is not necessary to assume that the interaction constants f_{rs}, etc., are all close to unity. The results agree much more closely with experiment than do those of any previous theory, and details will soon be published elsewhere. It seems,

therefore, that we are obtaining a better understanding of gas mixtures, and solutions other than those for which the regular assembly is a satisfactory model.

At the third session Prof. I. Prigogine (Brussels) described some recent work extending the Lennard-Jones and Devonshire model of liquids to binary mixtures at temperatures far from the critical point. In such systems it is possible to study the way in which the effective vibration frequency of a molecule in its 'cell' changes with concentration, and also how the mean size of the cells changes with concentration. It is found that both these effects have an influence on the thermodynamic functions, and give important corrections to the usual approximation of regular solutions. The magnitude of these effects has been calculated for the system carbon tetrachloride–carbon tetramethyl, and preliminary measurements give results in good agreement with the theory. Prof. Prigogine also reported some theoretical calculations in which account is taken of the presence in a liquid of Lennard-Jones cells containing 0 or 2 molecules. Such calculations lead to a much better value for the critical volume of a liquid; but, as yet, the work has not been extended to systems of more than one component. Other topics which arose in the succeeding discussion included the surface tensions of solutions composed of molecules of unequal size or shape; the variation of surface tension with composition gives a sensitive indication of the way in which molecules are oriented in a surface and supplements the information that can be obtained from the bulk thermodynamic properties.

The last session of the conference was devoted principally to the present experimental position. In his introductory paper Prof. D. H. Everett (Dundee) mentioned the scarcity of accurate data on the thermodynamic properties of solutions, and stressed the importance of choosing suitable experimental systems for the testing of particular statistical theories. Older work was concerned primarily with solutions departing little from ideality, but more recently both experimental and theoretical work has been concerned with departures from ideality due to flexibility and differences in shape. Prof. Everett discussed in some detail the system benzene–diphenyl, recently studied with concordant results by several different workers. As he pointed out, the results cannot be quantitatively interpreted in terms of a quasi-crystalline model with benzene occupying one site and diphenyl two; it seems that in dilute solution diphenyl must disorient the benzene structure, and perhaps for this reason the system is not a satisfactory one against which to test the theory. Prof. Everett directed attention to the useful supplementary information that may be derived from measuring non-thermodynamic properties such as viscosity, dielectric constant and absorption spectra. In the critical region very few reliable thermodynamic data are available; and here a few well-chosen measurements should greatly increase our understanding of such phenomena as the solubility of solids in vapours.

In the discussion, Mr. J. H. Baxendale gave a careful analysis of the experimental errors in his investigation with Dr. B. V. Enustin of the benzene–diphenyl system, and showed that the discrepancies with the simple theory are well outside the experimental errors. Dr. V. Mathot (Brussels) described a method of calculating the thermodynamic properties of a solution in which the solute consists of monomers and associated complexes. The activity coefficient of carbon tetrachloride in mixtures of this liquid with alcohols is found to fall between the value calculated from the Flory–Huggins model and the value appropriate to an 'ideal infinitely associated' solution. Further, it can be shown by the principle of detailed balancing that the ratio of activity coefficients of solute and solvent is equal to the fraction of solute molecules in the monomeric state; and this relationship is verified with great accuracy by spectroscopic measurements on the hydroxyl vibrational absorption band in its first and second overtones. This shows clearly that deviations from ideality are, indeed, due to the formation of complexes in these systems. Another observation which aroused great interest was the fact, reported by Dr. J. H. van der Waals (London), that the heats of mixing of hydrocarbons sometimes vary considerably with temperature; no satisfactory explanation has yet been found for this phenomenon.

Among the visitors who also took part in the conference were Dr. F. Booth (King's College, London), Mr. J. L. Copp and Mr. G. Duff (Dundee), Dr. M. J. S. Dewar and Dr. H. Tompa (Maidenhead), Dr. R. Freeman and Dr. W. Moffitt (Welwyn), Dr. E. L. Mackor (Oxford), Dr. P. Meares (Aberdeen), Dr. G. J. Szasz (American Embassy, London), Mr. Trappeniers (Brussels) and Dr. L. R. G. Treloar (Royal Institution, London).

H. C. Longuet-Higgins

OBITUARIES

Dr. L. J. Comrie, F.R.S.

Dr. Leslie John Comrie died on December 11 at his home in London at the age of fifty-seven. His health had been failing after a stroke two years ago, which left him with an active mind, but with much reduced capacity for work. He worked right up to the last, almost completing a project of long standing—a guide to errors in published mathematical tables.

Comrie was born at Pukekohe, New Zealand. He took a degree in chemistry at Auckland University College, before joining the New Zealand Expeditionary Force and serving in the First World War, during which he lost a leg. After the War he gave up chemistry for astronomy and computation, which were to be the great interests of his life. He was elected an Isaac Newton Student at Cambridge, and took his Ph.D. in 1923. He then spent three years in the United States, teaching astronomy and introducing computation into the student courses, first at Swarthmore College, then at North-Western University, Evanston, Illinois.

Returning to England, which he made his home, he served the Nautical Almanac Office first as deputy superintendent, then, during 1930–36, as superintendent. During this period he revolutionized the "Nautical Almanac" and its computation. By mechanizing calculation he greatly increased its range, accuracy and cheapness. This was reflected in great changes in the content of the "Nautical Almanac" itself—the major ones came first in that for 1931—which much increased its value as an astronomical tool.

In 1937 Comrie left the Nautical Almanac Office to found the Scientific Computing Service, Ltd., the first independent professional organization (and still the only one) to provide large-scale computation with high mathematical content. This organization, under

his directorship, has performed major computational work in many fields—for industry, for government departments and for universities. Emphasis was on accuracy, and on the lack both of dislike and of fear of computation—no job was ever turned down as being too large. When the Second World War broke out, one of Comrie's most valuable contributions consisted of two volumes of 200 pages of double-entry ballistic tables for the War Office, which were designed, computed, proof-read, printed and bound under his direction within the first twelve days of the War.

Comrie's main work was in the application of commercial machines to computational problems and in the construction of mathematical tables. He was opposed to the building of special calculating machines, but advocated always an examination of existing machines, available in considerable numbers, to see which was best adapted to the problem in hand. He was adept in devising special methods by which such machines could best be used, and in modifying the computational formulæ to fit the machines. He was never reluctant to tell a client that he was asking for unnecessary accuracy or results, or to point out that proposed methods were wrong or unduly lengthy.

One of his most constant objectives was the complete replacement of logarithmic computation by machine computation; he was always advocating the widespread adoption of calculating machines in all business and research establishments, and was always ready to advise on the choice of machine for each job to be tackled. It was his belief that, eventually, everyone who had need to compute should and would have a calculating machine. His experiences and judgment in this respect were acknowledged by the leading manufacturers and distributors of calculating machines, who could always be sure of advice based strictly on the merits of the machine and problem under discussion.

Comrie's work in preparing mathematical tables will probably form his most lasting memorial. At the Nautical Almanac Office and in collaboration with Prof. J. Peters of Berlin, he was interested in preparing tables of trigonometrical functions in exactly the form needed to help the computer most, and prepared several tables giving natural values to meet the needs of mechanical computation, for which logarithmic values are useless.

As secretary of the British Association Mathematical Tables Committee, he played a leading part in the preparation of most of the B.A. Mathematical Tables—achieving standards of typography and accuracy not previously considered attainable.

The "Standard Four-figure Mathematical Tables", prepared with Prof. L. M. Milne-Thomson, and his two revisions of Barlow's Tables are well known. So also are his last works to appear during his life-time, namely, his revision of "Chambers's Mathematical Tables"; the four-figure tables contain more useful tables, formulæ and ideas about tables and computing than have ever before been collected into 64 pages, while in the two volumes of "Chambers's Six-figure Mathematical Tables" he has prepared a set of tables replacing the old seven-figure tables, which should meet nearly all needs in the elementary field for many decades to come. In the introductions to these two volumes he has compressed an account of a very large proportion of his computational experience—they may almost be used as a text-book on general computational techniques. He was the first to believe that the maker of tables not only should, but also could, provide tables that were free from error. He believed, too, that it was his duty to give the user every possible aid and convenience. Comrie had an almost professional knowledge of typography, and the careful and expert attention which he always paid to this art, as well as to the logical austerities of the English language, set its mark on all his work.

Besides a great interest in the preparation of mathematical tables, Comrie had an equally powerful interest in other tables, and he conducted systematic and thorough searches for errors over very many years. His experience in these matters was very great, and it is fortunate that he had almost completed a record of this experience. This is to appear as part of a new edition of "An Index of Mathematical Tables", prepared by Fletcher, Miller and Rosenhead. The first edition of this "Index" was actively sponsored by Comrie, who financed publication through the Scientific Computing Service.

Comrie's outstanding contributions to the field he had done so much to extend and transform were acknowledged by election to the fellowship of the Royal Society last March. He was the first in this field to receive such recognition.

His experience and enthusiasm in computation and table-making will be very greatly missed. He will also be missed by his many astronomical and New Zealand friends, who could always be sure of interest, encouragement and help. J. C. P. Miller

Prof. J. W. Cobb, C.B.E.

On Saturday, November 25, John William Cobb died in Leeds at the age of seventy-seven. Educated at the Leeds Modern School, he entered the Yorkshire College (now the University of Leeds) in 1889. After graduating in the University of London at the age of nineteen, he went straight into industry with the Farnley Iron Co., Ltd., of Leeds. This firm manufactured certain high-grade local products—wrought iron and clay ware. John Cobb found himself in a works peopled with skilled craftsmen but without a scientific atmosphere. He was commissioned to learn by his own observation and experiment, but without a laboratory. His employers were in advance of the times and not lacking in encouragement. Thus he was able to advance the technique of the works, especially in the efficient use of fuel. In this way he acquired a reputation for knowledge of industrial gas heating. Endowed with curiosity and initiative, and thanks to the support of his employers, Cobb was able to carry out a considerable amount of investigation of works processes, notably on the solid reactions of silicates. In this, he showed himself ahead of his contemporaries.

In 1904 the Yorkshire College attained university rank and one of its first acts was to embark on the study of, and research on, fuels. This enterprise was the first of its kind in a British university. In 1906, a Department of Fuel and Metallurgy was established under the responsibility of Prof. W. A. Bone. He retained this position until 1912, when he took office in the new Department of Fuel at the Imperial College of Science and Technology.

In the meantime, the Fuel Department at Leeds had become associated with the science and technology of towns' gas. In 1910, when, by death, the British gas industry had lost one of its leading members, Sir George Livesey, it chose to use its resources to endow the chair of the new Department in Leeds. The departure of Prof. Bone to London

called for the appointment of a successor. Actually, no better choice could have been found than John W. Cobb. Appointed thus in 1912, he continued in office until 1938. In two years, however, the First World War broke out, followed by unforeseen problems. The Fuel Department at Leeds, the only one of its kind, had associations with the British gas industry, and the industry was faced with urgent technical problems arising from the War. To meet these needs, it was found necessary to establish a joint research organization between the University and the gas industry. This organization proved successful and led to extension and imitation. There is no doubt that the early success of these efforts owed much to Prof. Cobb's capacity and judgment.

H. J. Hodsman

Mr. C. E. C. Fischer

The death occurred on October 19, at the age of seventy-six, of Cecil Ernest Claude Fischer, formerly of the Indian Forest Service.

Born in Bombay on July 9, 1874, Fischer first went to school in Neuchâtel, Switzerland, and later to private schools in Brighton and Stratford-on-Avon. In 1892 he entered Coopers Hill College, Englefield Green, where he received his forestry training. He passed out of the College in September 1895 to join the Indian Forest Service in the Madras Presidency. From 1907 he acted as forest entomologist at the Forest Research Institute, Dehra Dun. During 1908–9 he was on furlough, taking special leave to study plant pathology in Munich and London. During the years 1915–17 he was principal of the Madras Forest College. He assisted the professor of forestry for four university terms at the School of Forestry, Oxford, during 1919–20. After his return to India in 1920, he became a conservator of forests, Madras, which post he held until he left at the end of 1923, finally retiring from the Indian Forest Service in 1926.

Retirement did not mean, however, a life of leisure for Fischer, but merely the dropping of his official duties in the Indian Forest Service and the commencement of a period of very useful work at Kew. In 1925 he was appointed assistant for India in the Herbarium of the Royal Botanic Gardens, where he remained until he reached the age limit in 1940. While at Kew he brought to a conclusion the late J. S. Gamble's "Flora of the Presidency of Madras", being responsible for the third volume of this work, from Ulmaceæ to the Gramineæ. Following Gamble's practice, he published explanatory notes during the progress of the "Flora" in the *Kew Bulletin*. He also published a number of other papers in the *Kew Bulletin*, including his important "Contributions to the Flora of Burma" (1926–40), "Plants New to Assam" (1929–40), "New or Little Known Plants from South India" (1932–39), and his determinations of "The Koenig Collection in the Lund Herbarium" (1932). His valuable "Survey of the Flora of the Animalai Hills" (1921) and "Flora of the Lushai Hills" (1938) appeared in the *Records of the Botanical Survey of India*. He described many new species, and in naming one of these he commemorated the Indian Forest Service.

Fischer had a strong sense of civic duty and served on many committees. During the War he was an air-raid warden, and while on duty in an air raid was injured and left permanently slightly lame. After the War he taught himself to make Braille books for the blind and became very proficient at this self-imposed task.

No one who knew Fischer could fail to appreciate his sterling integrity of character and the pleasant manner in which he discharged his manifold duties.

H. S. Marshall

We regret to announce the following deaths:

Prof. E. Abderhalden, editor of the well-known "Handbuch der biologischen Arbeitsmethoden", on August 5, aged seventy-four.

Sir Leonard Parsons, F.R.S., emeritus professor of paediatrics and child health in the University of Birmingham, on December 17, aged seventy-one.

NEWS and VIEWS

New Year Honours

The following names of scientific men and others associated with scientific work appear in the New Year Honours list:

K.B.E.: Mr. Harry Mason Garner, chief scientist, Ministry of Supply; Dr. Arthur Elijah Trueman, chairman, University Grants Committee.

Knights: Dr. Frank Macfarlane Burnet, director of the Walter and Eliza Hall Institute for Medical Research, Melbourne, for services to biological research; Mr. Thomas Dalling, chief veterinary officer, Ministry of Agriculture and Fisheries; Prof. Thomas Henry Havelock, emeritus professor of mathematics, King's College, Newcastle upon Tyne; Mr. Christopher Hinton, deputy controller of Atomic Energy (Production), Ministry of Supply; Dr. Gordon Morgan Holmes, consulting physician, Charing Cross Hospital and National Hospital for Nervous Diseases; Mr. Henry Thirkill, master of Clare College, Cambridge, and chairman of the Cambridge University Joint Recruiting Board.

C.B.: Mr. E. Barnard, deputy secretary, Department of Scientific and Industrial Research; Mr. W. R. J. Cook, chief of the Royal Naval Scientific Service, Admiralty; Dr. W. F. P. McLintock, lately director of the Geological Survey and Museum.

C.M.G.: Mr. W. Abbott, H.M. inspector of schools, Ministry of Education; Dr. W. J. Hall, director of the Commonwealth Institute of Entomology; Dr. C. F. Hickling, fisheries adviser to the Secretary of State for the Colonies; Mr. J. C. Muir, Colonial Agricultural Service, member for agriculture and natural resources, Tanganyika; Mr. H. J. Page, principal of the Imperial College of Tropical Agriculture, Trinidad; Dr. G. L. Sutton, for services to agriculture in Western Australia.

C.B.E.: Mr. K. Baumann, for services to turbine development; Mr. H. J. Braunholtz, keeper of the Department of Ethnography, British Museum; Mr. S. E. Chisholm, assistant controller, Patent Office; Mr. Hayne Constant, director of the National Gas Turbine Establishment, Ministry of Supply; Dr. Oscar Faber, for services in the rebuilding of the

House of Commons; Dr. A. H. R. Goldie, deputy director (research), Meteorological Office, Air Ministry; Mr. W. H. Guillebaud, deputy director-general, Forestry Commission; Mr. W. L. M. O'Connor, director of carbonization, National Coal Board; Mr. J. E. Serby, deputy director, Royal Aircraft Establishment, Farnborough; Prof. A. N. Shimmin, professor of social science in the University of Leeds, for services as a member of the National Arbitration Tribunal; Dr. S. L. Smith, director of research, British Shipbuilding Research Association; Dr. V. B. Wigglesworth, director of the Unit of Insect Physiology, Agricultural Research Council; Mr. R. Yates, deputy chief inspector of mines, Ministry of Fuel and Power.

Astronomical Observatories at Mount Stromlo, Australia

For some years the Yale and Columbia Universities have jointly operated a Southern Station at Johannesburg, but they have recently become embarrassed by the deterioration of astronomical observing conditions in that city, due to its industrial development. It became necessary to seek a site in some country locality, and the two American Universities have accepted an offer made by the Australian Government to set up the Station on Mount Stromlo next to the Commonwealth Observatory. It is now planned to move the principal telescope, which is a refractor of 26 in. aperture and 400 in. focal length, late in 1951, and to erect a wide-field camera of 8 in. aperture and 80 in. focal length at about the same time. The station will be under the charge of Mr. Cyril Jackson, who will carry out programmes as arranged by the directors of Yale and Columbia Observatories, Dr. Dirk Brouwer (who visited Mount Stromlo in November and December) and Jan Schilt. It is expected, however, that there will be some interchange of observing time with the Commonwealth Observatory.

It is proposed to continue photographic determinations of stellar parallax, proper motions, mass ratios of binary stars and of the positions of minor planets, and photo-electric determinations of stellar magnitude. Provision of a visual correcting lens and of an objective prism for the long-focus refractor is under consideration. This telescope will complement the 74-in. reflecting telescope now being constructed for Mount Stromlo by Messrs. Sir Howard Grubb, Parsons and Co., and the old Melbourne 48-in. telescope which is being re-erected on Mount Stromlo as a Schmidt camera; and it is hoped that co-operation between the Yale–Columbia observers and those of the proposed Swedish observatory on Mount Stromlo with the staff of the Commonwealth Observatory and of the Australian National University will prove fruitful of astronomical results.

Medical Aspects of Atomic Warfare

The real danger that atomic warfare may be employed in a further world conflict makes the symposium on its medical aspects, organized by *The Practitioner* with the advice of Sir Ernest Rock Carling, and published in its December issue, specially timely. Its aim is to provide essential information on the hazards of atom bomb explosions. Ten articles, written by experts, cover very briefly the physical, biological, genetical and medical aspects. The contributors to the symposium have taken advantage of the various official publications and personal reports concerned with the atomic explosions at Hiroshima and Nagasaki. One of the papers deals with the assessment of possible casualties and damage which might be caused by an atom bomb bursting over a British city, and contains many thought-provoking if unpleasant data. A proper distinction is drawn between gross pathological lesions, which are well summarized, and the deleterious genetical effects manifesting themselves only in later generations and the distant future. The information given in these ten articles, though chiefly directed to the medical profession, will undoubtedly be useful to all concerned with our defence and safety. In an editorial comment it is suggested that medical men in possession of such knowledge will be able "to calm the fears of our more apprehensive patients", and keep up the morale of the population; we must, however, remain of the opinion and hope that if this information concerning the consequences of an atom bomb attack is shared by an adequate number of the potential "patients" themselves, the ghastly prospect may yet become sufficiently remote.

Catalogue of Economic and Social Projects of the United Nations

The "Catalogue of Economic and Social Projects, 1950" (pp. 515; Lake Success, N.Y.: United Nations; London: H.M. Stationery Office, 1950; 3.75 dollars or 27*s.* 6*d.*), issued by the United Nations secretariat at the request of the Economic and Social Council, lists, describes and classifies the work during 1949 of the secretariats of the United Nations and of the Specialized Agencies in the economic and social fields. The main bulk of the information, which includes research studies and investigations as well as technical services and other operational activities, is set forth under the different departments responsible, first of the United Nations and then of the Specialized Agencies; but the analytical index which constitutes Part 2 of the Catalogue brings together, under headings representing the main sectors of the economic and social field, the work of the United Nations and the Agencies related to each sector. The subject headings, adopted for this classification as a result of consultation among the Agencies and the United Nations, represent a compromise and are regarded as experimental. There is some repetition, but they do assist in giving a fairly coherent picture of the work going on in particular fields, though no complete picture is given of what is taking place in science or in any one branch of science. Although the Catalogue is not primarily a bibliography, much bibliographical information on reports and other published documents is included. Not the least useful features are the two lists appended, giving the libraries where documents of the United Nations and of the Specialized Agencies can be consulted, and U.N. information centres and the sales depots where documents of the Specialized Agencies are available.

Nuffield Foundation Awards for Biology and the Social Sciences

As an experiment during the next three years, the Nuffield Foundation is offering annually a small number of scholarships and bursaries in biology and in the social sciences (excluding economics) for British graduates of about 22–35 years of age, which will be tenable initially for one year but renewable up to three years. The awards in biology are for persons who have graduated in the physical sciences or in mathematics and who wish to pursue a course of further training in biology. The scholarships are for those with some previous postgraduate experience

and are worth £500–600 with additional allowances of £50 if married and £50 for each of the first two children, together with travelling expenses, etc., where applicable. The bursaries are for those who have recently graduated and are worth £350, with the allowances already quoted. The awards for the social sciences are the same as those for biology except that the holder may have a degree in any subject other than the social sciences, though one in natural science is preferable. Application forms, to be completed by May 1, can be obtained from the secretary of the Nuffield Foundation, 12–13 Mecklenburgh Square, London, W.C.1.

University of London

The following announcements have been made by the University of London: Dr. F. M. Haines, reader in botany at Queen Mary College, has been appointed to the University chair of botany tenable at the College. The title of professor of papyrology in the University has been conferred on Mr. E. G. Turner in respect of the post held by him at University College. The following doctorates have been conferred: *D.Lit.*: Prof. L. Dudley Stamp (London School of Economics); *D.Sc.*: Mr. S. J. Y. Edwards (Royal Veterinary College); Miss A. M. Robinson (Bedford College and University College).

University of St. Andrews

The following appointments in the University of St. Andrews have been announced. Dr. W. L. Burgess, reader in public health, to the new James Mackenzie chair of public health and social medicine; Dr. E. F. Freundlich, Napier lecturer in astronomy, to the new Napier chair of astronomy.

Exhibition of Recent French Scientific and Technical Publications

A small collection of recent French publications in different branches of science and technology, arranged by the Cultural Relations Department of the French Foreign Office with the assistance of the French Publishers' Association, is being shown in Great Britain during the coming months. The exhibition will be at the Science Library, Imperial Institute Road, London, during January 13–23 inclusive; at the Radcliffe Science Library, Oxford, during January 29–February 6; in the Great Hall of the University of Birmingham during February 13–20; at the Mitchell Library, Glasgow, during March 12–20; and at the Central Library, Sheffield, during April 30–May 12. Admission will in all cases be free and without ticket. The exhibition will be inaugurated on January 12 at 6.15 p.m. in the Science Library, when short addresses will be given by Dr. F. Sherwood Taylor, director of the Science Museum, and Mr. J. D. Newth, president of the Publishers' Association of Great Britain.

The Night Sky in January

New moon occurs on Jan. 7d. 20h. 10m., U.T., and full moon on Jan. 23d. 04h. 47m. The following conjunctions with the moon take place: Jan. 10d. 02h., Mars 2° N.; Jan. 11d. 08h., Jupiter 0·2° N.; Jan. 27d. 23h., Saturn 4° N. Mercury, in inferior conjunction on January 1, rises at 6h. 30m. and 6h. 40m. on January 15 and 31 respectively, and can be seen in the eastern sky for a short time; but the planet has a large southern declination and will not be a conspicuous object in the British Isles. Venus sets three-quarters of an hour after the sun on January 1 and an hour and a half after on January 31, and is visible in the western sky, stellar magnitude −3·4, practically all the luminous disk being visible. Mars sets at 18h. 45m., 18h. 55m. and 19h. 05m. on January 1, 15 and 31 respectively. In the early part of the month the planet is close to θ Capricorni, and about the middle of the month it moves into the constellation of Aquarius. Jupiter sets at 20h. 55m., 20h. 10m. and 19h. 30m. on January 1, 15 and 31 respectively, and can be seen a little east of Mars. Saturn rises at 23h. 30m., 22h. 30m. and 21h. 25m. at the beginning, middle and end of the month respectively, and is close to η Virginis during this time. Occultations of stars brighter than magnitude 6 are as follows: Jan. 2d. 5h. 23·9m., *i* Virg. (*R*); Jan. 17d. 22h. 28·5m., 16 Taur. (*D*); Jan. 17d. 22h. 37·4m., 17 Taur. (*D*); Jan. 17d. 22h. 56·2m., *q* Taur. (*D*); Jan. 17d. 23h. 07·2m., 20 Taur. (*D*); Jan. 17d. 23h. 31·5m., 21 Taur. (*D*); Jan. 26d. 23h. 09·9m., τ Leon (*R*); Jan. 29d. 02h. 08·8m., 49 Virg. (*R*). *R* and *D* refer to reappearance and disappearance respectively, and Greenwich is assumed as the place of observation. The earth reached perihelion on January 2.

Announcements

A course of ten lectures under the title "An Introduction to the Science of Nuclear Power" is to be given in the Electrical Engineering Department of the Imperial College of Science and Technology on Fridays at 4 p.m., commencing January 12, the lecturers being Dr. O. Buneman, J. Diamond and R. V. Moore, of the Atomic Energy Research Establishment. Applications for admission should be addressed to the Deputy Registrar, City and Guilds College, Exhibition Road, S.W.7.

The symposium on "High-Temperature Steels and Alloys for Gas Turbines" arranged by the Iron and Steel Institute, and the Hatfield Memorial Lecture of the Institute to be delivered by Sir Frank Whittle, postponed from October 17–19 of last year, will take place during February 20–22. Sir Frank Whittle will give his lecture at the Caxton Hall, London, S.W.1, on February 20 at 8.30 p.m.; the symposium will be at the Institution of Civil Engineers, Great George Street, London, S.W.1, during the succeeding two days.

A colloquium on the "Chemotherapy of Tuberculosis" will be held in Dublin during July 10–13. The lecturers will include Dr. V. C. Barry (Medical Research Council of Ireland), Dr. Marc Daniels (Medical Research Council, London), Prof. G. Domagk (Wuppertal–Elberfeld), Dr. W. H. Feldman (Mayo Foundation), Dr. P. D'Arcy Hart (Medical Research Council, London), Mr. T. J. D. Lane (Meath Hospital, Dublin) and Dr. Edgar Lederer (Institut de Biologie Physico-Chimique, Paris). Further information can be obtained from J. G. Belton, honorary secretary of the organizing committee, at the Laboratories, Medical Research Council of Ireland, Trinity College, Dublin.

As from January 1 the six sections, *A* to *F*, of the *Canadian Journal of Research* are being published as separate journals. The present title will cease to be used, and the new titles of the separate journals are *Canadian Journal of* [respectively] *Physics*, *Chemistry*, *Botany*, *Zoology*, *Medical Sciences* and *Technology*. The present sequence of volume numbers is retained, the 1951 issues being numbered Vol. 29. The subscription-rates are unaltered.

EVOLUTION OF THE AFRICAN CICHLID FISHES: THE *HAPLOCHROMIS* SPECIES-FLOCK IN LAKE VICTORIA

By P. H. GREENWOOD

REGAN[1] concluded that the primary evolution of the endemic species of *Haplochromis* in Lake Victoria had involved adaptive radiation towards different types of food and feeding methods. He further stressed that the basic stock from which they had evolved is represented to-day by *Haplochromis cinereus* Boulenger. Subsequent work has provided a clearer picture of the ecology[2,3] and geological history of the lake which, together with the impression gained from a revision of the Victoria species of *Haplochromis*, has enabled me tentatively to formulate a more detailed outline of the evolution of these fishes.

In Lake Victoria the genus is represented by about sixty species, which may be referred to the following three morphological groups, indicating three peaks of ecological adaptation. Within each group further micro-adaptation may be observed, especially in the first and the third.

Group 1 ('*Cinereus* Group'—twenty-four species). Mouth horizontal, jaws equal, outer teeth bicuspid even in the adult, snout short in relation to the eye, body deep. Ecologically a bottom-feeding inshore complex, regarded as the modern representatives of the stock from which the second and later the third groups were evolved.

Group 2 ('*Guiarti* Group'—seventeen species). Mouth slightly oblique, lower jaw prognathous, dentition variable but conical and caniniform, outer teeth predominating, snout longer than in Group 1, body more slender. Shows affinities both with the preceding and with Group 3. Predaceous piscivorous species, inhabiting the middle depths of open and inshore waters.

Group 3 ('*Acutirostris* Group'—eighteen species). Mouth very oblique and in two species almost vertical, lower jaws strongly prognathous, outer teeth caniniform, snout long, body slender. Clearly derived from Group 2. Predaceous surface-feeding species, mainly insectivorous and piscivorous.

The evolution of these three species-complexes appears to have been intimately connected with the climatic fluctuations and tectonic movements which affected the Central African plateau from Miocene to late Pleistocene times.

The Miocene lake ("Lake Karunga" of Wayland[4]) resulted from the flooding and interconnexion of swamps lying in the depression formed by early Tertiary tectonic activity. The Cichlidæ of this lake are known only from fragmentary fossil remains obtained at Rusinga Island. Generic diagnosis of these has so far proved impossible, but they represent a small generalized form which may possibly be related to *Tilapia nilotica*. During the Miocene, Lake Karunga seems to have risen quite considerably and encroached upon the swampy ground lying to the west[4]. Work now in progress shows that the genera *Lates* and *Polypterus* were present in this lake, the fauna of which was probably destroyed during a period of aridity at the close of the Miocene. Neither of these genera is represented in the present lake, and it is concluded that the fish fauna of Lake Karunga was completely destroyed. During the Pliocene the east–west river systems must have started flowing again, filling the swamps lying in the basin of the future Lake Victoria[4]. Recolonization of these swamps was, perhaps, from the eastern rivers, for example, the proto-Tana and Athi River systems. Evidence for this is derived from the presence of *Tilapia nigra* (a species at present confined to the Athi River) in Pleistocene deposits at Rawe[16]. The fact that *Lates* and *Polypterus* are to-day absent from the eastern rivers as well as from the lake, although they occur in the Nile and the western river systems, may be negative evidence pointing to the same conclusion. Throughout the Pliocene the embryo lake, responding to changes in climate and physiography, alternated between a series of more or less disconnected swamps and a much-branched sheet of water.

Conditions provided by the developing lake would allow for the evolution of *Haplochromis* Groups 1 and 2; Group 1 during the Pliocene and Group 2 during the later Pliocene and early Pleistocene. Small populations of fishes would have been isolated in the swamps, while the gradual filling of the lake basin would allow for migration between previously isolated areas, as well as providing new ecological niches for occupation. Group 1 appears to have evolved during the Mio-Pliocene phases of lake development when conditions were predominantly of the swamp or shallow-lake type. When the lake began to fill during the First Pluvial, a suitable habitat for Group 2 came into being. Here again, division of the lake into several distinct areas of fairly deep water provided the spatial isolation and re-directed selection-pressure necessary for the initiation of evolutionary processes. It seems unlikely that Group 3 could yet have evolved since it is absent from the present fauna of Lake Edward (see below).

From the evidence of the Cichlidæ in Lake Edward[5], we may conclude that the Lower Pleistocene species-flocks of Lake Victoria were represented by a highly evolved Group 1 and more generalized Group 2 complex. During the First Pluvial (Lower Pleistocene), Lake Edward, then continuous with Lake Albert, was connected to Lake Victoria through swamps and streams extending over the area now occupied by the Kagera River valley[6,7,8], with consequent dispersal of the Victoria fishes. The connexion was effected by the drowning of the Ankole river valleys, with subsequent river reversals due both to tectonic activity and the rising level of Lake Victoria.

With five exceptions, all the *Haplochromis* species of Lake Edward are endemic. Dr. E. Trewavas (personal communication) favours the consideration of some, at least, as sub-species of the Lake Victoria forms to which they are so closely related. Only two species belong to Group 2, the remainder being of Group 1 and including some of the highly specialized algal and mollusc feeders.

From the similarity of the two populations, I conclude that by the Lower Pleistocene the Group 1 *Haplochromis* in Lake Victoria had reached a state in their evolution comparable with that of the present population. It is not possible to draw such conclusions for Group 2, since it is represented in Lake Edward by only two species of the generalized type.

With the beginning of the Middle Pleistocene there was a period of considerable aridity, the First Inter-Pluvial, during which the continuity of Lakes Albert and Edward was lost, and presumably also that of Lakes Edward and Victoria. Worthington[9] (based on Wayland) concluded that Lake Victoria was reduced to a few pools capable of supporting very little life and that, when the lake was refilled by the increased rainfall of the Second Pluvial (Post-Middle Pleistocene), the present fauna was derived from the neighbouring drainage-systems and a few endemic survivors. While not denying the relatively severe aridity of that period (see Solomon[8] and Moreau[10]: the latter considers that the rainfall was a little less than at present), I do not consider that the lake dried out completely. The existence of the Victoria–Edward species complex seems to favour this assumption. Rather I believe that, during the Inter-Pluvial, Lake Victoria was reduced to a smaller central body flanked by swampy pools and rivers—that is, a repetition of Pliocene conditions and consequently a period of further evolutionary potentiality.

This Inter-Pluvial was succeeded by a second Pluvial, though of less intensity than the first. As a result, Lake Victoria was refilled and there was a return to the open-water conditions that prevailed during the lower Middle Pleistocene[12].

With the restoration of these open-water conditions the ecological zone peculiar to the extant species of Group 3 became available for colonization, and it is to this period that I attribute its evolution. Species of Group 2 that survived the adverse conditions of the Inter-Pluvial and retained their evolutionary plasticity seem to have supplied the stock from which Group 3 evolved.

The early isolation necessary for its evolution was probably due primarily to intrinsic factors rather than the extrinsic spatial factor responsible for the evolution of Groups 1 and 2. Until more is known of the ecology and ethology of Group 3, the postulated isolating factors of specialized feeding and breeding habits[13] must remain highly conjectural.

After the Second Pluvial there appear to have been two Post-Pluvial wet phases[11,12] which did not affect the lake to any appreciable degree, and therefore had little effect upon the major evolutionary trends exhibited by the three groups.

The African Cichlidæ have previously been considered as examples of sympatric speciation[9]. Mayr[14] questioned this concept and postulated multiple invasion to account for the species-flocks. This process may have played a part in the early evolution of Group 1, as at that time Lake Karunga lay in the drainage basin of several Kenya rivers which crossed the area on their way to join the Congo river-system. Later evolution, taking place under the conditions outlined above, would be of the usual allopatric type. Brooks[15] suggests that the principle of allopatric speciation is applicable to all the species-flocks characterizing 'ancient lakes'. Also he has shown that ecological differences in Lake Nyasa, correlated with specialized feeding-habits, would provide the necessary spatial isolation to account for the Cichlid flocks of that lake.

Worthington[9] and Brooks[15] consider that the major evolution of Lake Victoria's Cichlidæ has taken place since the Second Pluvial. For the reason outlined above, I would consider the evolution of the flocks to be divisible into two major periods, namely, first, Pliocene to early Middle Pleistocene, and secondly, Post-Middle Pleistocene to Upper Pleistocene. To the first division belongs the evolution of the majority of Group 1 and the more generalized species of Group 2, while the evolution of Group 3 and the more specialized members of Groups 1 and 2 may be referred to the second division.

I wish to express my gratitude to the Trustees of the British Museum (Natural History) for the facilities provided while working in the Department of Zoology as a Colonial Office fisheries research student, and to Dr. E. Trewavas and Mr. D. W. Tucker for their assistance and encouragement.

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INFORMATION THEORY

DURING the past hundred years or so a variety of techniques has been devised for transmitting messages electrically from one point to another. It is only of recent years, however, through the work of a few theoretically minded communication engineers, that means have been provided for assessing quantitatively the commodity which is transmitted, namely, the 'information' content of messages, and of determining the extent to which existing techniques fall short of what may be attainable. This recent work proves to have a significance beyond the sphere of electrical communications. A new branch of science is emerging which reveals and clarifies connexions between previously largely unrelated fields of research concerned with different aspects of the processes by which living organisms—in particular man—collect, classify, convert and transmit information. A confluence of different fields of investigation is, of course, no new phenomenon in the history of science, but the wide recognition of a new connecting link can seldom have been so rapid as in the present case.

With the view of affording an early opportunity for discussion of the nature and potentialities of this recent work among interested scientific workers and technologists, a symposium was held in the rooms of the Royal Society during September 26–29. The hundred and thirty members of the symposium included groups of mathematicians, statisticians, physicists, biologists, physiologists, psychologists and electrical engineers. Attendance from abroad, though limited by the available accommodation to twenty-five, was strong and representative, as may be judged from the names of Profs. B. van der Pol, G. H. Bast, H. Dahl, P. Grivet, B. Haard and J. L. van Soest. The two invited foreign speakers were Dr. Claude E. Shannon, of the Bell Telephone Laboratories, New York, and Prof. J. B. Wiesner, of the Electronics Laboratory, Massachusetts Institute of Technology. The other speakers were from Great Britain, but the visitors from the

Continent of Europe contributed extensively to the prolonged and lively discussions. Sir David Brunt and Profs. H. S. W. Massey, R. A. Fisher, W. E. le Gros Clark, E. D. Adrian, J. L. van Soest and Dr. R. Cockburn acted as chairmen of individual sessions.

After Sir David Brunt had opened the symposium and welcomed the visitors in the name of the Royal Society, a short introductory address was given by the organizer, Prof. Willis Jackson. E. C. Cherry then presented a historical review of the evolution of the theory of information. Starting from a discussion of languages and codes, he proceeded to the history of electrical communication techniques, and to the gradual development of what is now called communication theory. After several workers from about 1924 onwards had shown the way for a determinate mathematical description of communication signals, Norbert Wiener and C. E. Shannon introduced the statistical aspect. The 'terminal equipment' can be human or instrumental. The generality of the concepts, and of their mathematical representation, lead naturally to inquiry into possible similarities between the information-handling abilities of the human brain and of calculating machines. A further step leads to consideration of the reaction of the receiving system on the source of information, a field common to servo-mechanisms and living organisms, to which Norbert Wiener has given the name 'cybernetics'. Finally, the quantitative features and methods which have emerged from these studies throw light on the general problem of the assessment of information about Nature, that is, on experimental science in the most general sense of the term. This is the subject of information theory proper, of which only some outlines are visible for the time being. The fifty-three references which accompanied Mr. Cherry's paper will be a welcome guide for those who wish to study the subject.

Dr. Claude Shannon gave a concise exposition of the statistical communication theory which he has formulated in a number of important publications[1]. The 'information'—not to be confused with 'meaning'—conveyed by a signal, whatever form this may take, is measured by its unexpectedness on the basis of a known statistical distribution, and is mathematically expressed by the 'selective entropy' of the ensemble from which it is taken. *A priori* knowledge restricts this ensemble, and a judicious use of this knowledge may lead to economy in communication technique, by reducing the redundancy in the transmission. Dr. Shannon dealt particularly with his more recent researches, which suggest that, if account is taken of the long-range statistical structure of the English language, its redundancy may be as high as 75 per cent. In a further, written, communication Dr. Shannon gave a summary of his theory of coding, but his second lecture dealt instead with an entirely new contribution to the subject. His new approach is related to J. von Neumann's 'partition theory' of information, and to G. Birkhoff's 'lattice theory'. The lattice is a collection of stochastic processes, represented by points in an abstract space, with a metric so determined that equivalent processes obtained by encoding operations reversibly from one another count as one point, and the distance between two points measures the statistical independence of the processes which the points represent. If x and y are two processes, their interval is the sum of the conditional entropies $H_x(y) + H_y(x)$. It is hoped that the new approach will open the way to the difficult and practically important problem of using the reaction of the receiver for correcting errors in the transmission.

An account of his investigations on the relation of communication theory to physics was given by Dr. D. Gabor[2]. Signals are restricted *a priori* by the method of physical analysis to a finite number of data, but there is no mathematical reason why the accuracy of the measurement of each datum should be limited. There are, however, three physical reasons, corresponding to temperature, the discreteness of the elementary electric charge, and the finiteness of the quantum of action. If all other, non-fundamental, sources of 'noise' are eliminated, there remains a fundamental uncertainty, which defines a scale of smallest distinguishable steps, similar to the scales used in physiology. He showed also that quantum noise, unimportant at present in electrical communication problems, will be met with sooner than expected if progress continues towards higher frequencies.

A contribution on "Quantal Aspects of Scientific Information", by D. M. MacKay[3], gave an appropriate frame for the unification of apparently divergent definitions of 'amount of information'. *A priori* or structural and *a posteriori* or metrical information are complementary indexes of 'descriptive-content'. Both are quantized, the first by logical necessity, the second by noise or other physical causes of finite accuracy. Selective information is an index of statistical rarity, applicable to ensembles of descriptive patterns. It may be hoped that the terminology which he presented in an extensive glossary will be used by future contributors to the subject.

Prof. M. S. Bartlett gave an extensive review of the "Statistical Approach to the Analysis of Time-Series", a subject of great importance in communication theory and in scientific methodology. He reminded the audience that the first statistical definition of information was given by R. A. Fisher, long before the information (entropy) concept was introduced into communication theory, and discussed their respective association with inference and specification problems. Statisticians are largely concerned with inference, and physicists with specification; but they may still have much to learn from each other. Perhaps the most interesting contribution in Prof. Bartlett's review concerns a method of smoothing in the harmonic analysis of time-series, which he has developed[4].

In a lecture on the "Theory of Radar Information"[5], P. M. Woodward gave an interesting illustration of the application of Shannon's communication theory by consideration of the problem of measuring the range of a stationary target. He showed that there are two quite different conditions of reception—one, ambiguous reception in which the information-rate is high but the intelligibility low; the other, unambiguous reception in which the reverse is the case—and he suggested, therefore, that merely to evaluate quantities of information, and compare them with ideal limits, is not an adequate guide to the behaviour of a communication system. Some figure of intelligibility may also be necessary in particular problems.

Until quite recently the subject of noise in relation to electronic devices has been a highly controversial one, and much credit for its clarification must go to Dr. D. K. C. MacDonald, who gave a review of "Fluctuations and Theory of Noise". Considerable confusion has been caused by the 'time approach' and 'frequency approach' being considered as apparently independent, whereas both specifications contain

essentially the same physical information. Another source of error, dealt with in the discussion, lies in the attempt to apply classical thermodynamics to electron stream problems where thermal equilibrium is not, in fact, attained.

On the third day attention was transferred from branches of scientific effort in which information theory has already a secure foothold to those in which its application is still largely a matter of conjecture. Dr. D. B. Fry spoke on the problems of linguistic theory, in particular on the problem of speech recognition. Dr. T. Gold reviewed his and Prof. R. J. Pumphrey's theory of hearing[6], for which important indirect supporting evidence has lately been forthcoming. Dr. W. A. H. Rushton explained that some hundreds of retinal receptors share only a single nerve fibre to the brain, and yet provide an optic signal in which are encoded enough features of the observed scene, not only to stimulate automatic movements, but also to form the basis of visual judgment. He asked, in effect, how the communication engineer would deal with such a situation using a line subject to the usual limitations of nerve transmission, namely, no frequency greater than 500 c./s. and no variation in amplitude? What are the features of a scene which, with these limitations, it would be most advantageous to abstract and transmit, and can theory lay down the conditions in which experimental observations will give definite answers? Not surprisingly, these questions went unanswered, but they served to illustrate the emerging interrelationships. Dr. W. E. Hick showed that material collected by experimental psychologists on the dependence of choice reaction-time on the degree of choice permitted can be represented with remarkable accuracy by a logarithmic curve, as if the brain carries out the choice, for example, by a succession of binary selections, with fixed time for each. Dr. W. Grey Walter gave a description of two electro-mechanical devices which he has constructed to provide an imitation of the superficial features of animal behaviour, and which demonstrated that a small number of receptors and effectors is sufficient to produce very complicated behaviour patterns. Dr. J. A. V. Bates outlined some problems in neurophysiology on which speculation by communication engineers might be fruitful, and supplied a glossary for a first introduction of physicists and engineers to this field.

Dr. A. Uttley reviewed the operation of computers as transformers or coders of information, and demonstrated in a striking manner that machines can already perform several functions previously regarded as attributes only of living organisms, such as learning from past experience, or recognizing abstract patterns, even of the type which are held to be tests of intelligence—interest in machines which can play games seems to be fairly widespread among the mathematicians who have made contributions to information theory. Dr. Shannon is engaged in constructing a machine which will not only play chess, but even improve its game. A tentative theory of 'maximum mobility' was presented in an interesting contribution by Dr. Eliot Slater on the basis of the statistics of master-games.

On the final day, J. H. Westcott gave a lucid review of "Criteria of Prediction and Discrimination". In this field the pioneer work has been done by Norbert Wiener, but his criterion of 'least mean square error' is not always satisfactory. Westcott advocated a 'time-weighted' criterion, which may prove superior once the mathematical difficulties connected with its application are overcome. This was followed by a discussion opened by D. M. MacKay on entropy, time and information, in which the suggestion was made that the 'arrow of time' is determined by the direction in which our information increases. The concluding talk was given by Prof. J. B. Wiesner, who described the work being carried out in the United States and at the Massachusetts Institute of Technology in particular, on the difficult problem of speech recognition using 'visible speech', and on electronic correlators[7].

The subject-matter of the papers and of the discussions which followed their presentation is to be reproduced in composite form with the assistance of the Ministry of Supply, which also, with the support of the British Broadcasting Corporation, generously contributed to the costs of the symposium. Applications for copies of the proceedings should be sent to the Electrical Engineering Department of the Imperial College of Science and Technology, London, S.W.7, and will be met as equitably as possible from the limited number which can be made available.

Willis Jackson

[1] Shannon, C. E., *Bell. Syst. Tech. J.*, **27**, 379, 623 (1948); *Proc. Inst. Rad. Eng.*, 10 (1949).
[2] Gabor, D., *J. Inst. Elec. Eng.*, **93**, III, 429 (1946); *Nature*, **159**, 591 (1947).
[3] MacKay, D. M., *Phil. Mag.* (7), **41**, 289 (1950).
[4] Bartlett, M. S., *Nature*, **161**, 686 (1948); *Biometrics*, **37**, 1 (1950).
[5] Woodward, P. M., and Davies, I. L., *Phil. Mag.*, (7), **41**, 1001 (1950).
[6] Gold, T., and Pumphrey, R. J., *Proc. Roy. Soc.*, B, **135**, 462 (1948).
[7] Lee, T. W., and Wiesner, J. B., *Electronics*, **23** (June 1950).

CONFERENCE ON BIOLOGICAL ANTIOXIDANTS

THE volume under review* contains the transactions of the Third Conference on Biological Oxidants held in New York in October 1948, and also a report on the Symposium des Lipides held in Paris during January 1948. In both, the familiar pattern of a verbatim record is followed. This has both its advantages and disadvantages. Comments and questions directed to the principal speaker are often the means of clarifying obscurities in argument or of eliciting speculations which add greatly to the value of the symposium. Nevertheless, it must be admitted that the spoken word often lacks precision and that interpolations like 'Dr. X, did you want to ask something?' can be irritating. To the participants in the conference the situation would have been quite different.

There are in this volume ten papers, each followed by a discussion. They range from a general introduction on "The Mechanism of Autoxidation and the Action of an Antioxidant" by L. Michaelis to "The Mechanism of Action of Lipoxidase" by R. T. Holman; but, as was inevitable in any symposium on this topic, the biochemistry and biological action of tocopherol were never far out of the picture.

A very interesting paper is contributed by the chairman, Prof. Paul György, on "Observations on the Biological Effect of Tocopherol in Living Organisms", in which he describes his experiences with various diets causing hepatic necrosis in rats and shows that not only methionine but also tocopherol can prevent the development of such necrosis. He inclines towards the interpretation of their action as

* Biological Antioxidants. Transactions of the Third Conference, Oct. 7-8, 1948. Edited by Cosmo G. Mackenzie. Pp. 146. (New York: Josiah Macy, Junior, Foundation.) 2.70 dollars.

one of detoxication. In the same paper he records that tocopherol administration to rats can prevent the hæmolytic action of alloxan, but not its necrogenic effect upon the pancreas.

Another interesting paper is that by W. G. Clark and T. A. Geissman on "The Role of Flavonoids and Related Substances in Biological Oxidations". The authors stress the important effects which may follow the capacity of substances of this class of chelating with metals such as iron, copper, cobalt and zinc.

Taken as a whole, the volume is stimulating, although it is now some considerable time since the conferences took place. One feels, perhaps, that the contributions might just as well have found their way into the recognized journals where they would have attracted the attention of both specialists and those more generally interested in these topics. As it is, the volume recording the conferences is likely to find its way into the bookshelves of the specialists only. They will no doubt be glad to have all the material conveniently assembled under a single cover.

NUFFIELD FOUNDATION

ANNUAL REPORT FOR 1949-50

DURING its first quinquennium the Nuffield Foundation selected and supported projects which seemed likely to advance the frontiers of knowledge in the medical, natural and social sciences, and particularly projects which seemed likely to contribute to the betterment of life. Many of the Foundation's earlier interests are being further pursued or rounded off as part of its present programme, and the Foundation announced in its fourth annual report its intention of seeking opportunities of furthering the search for new knowledge, especially in the fields of biological and sociological studies, and also of supporting or initiating attempts to apply existing knowledge to practical problems of contemporary importance. In its support of fundamental research, the Foundation has manifestly sought to assist work in fields which would often otherwise be neglected and thus to restore some balance in the advancing front of science.

Not content with its earlier efforts to break into new ground, to nurture some of the more immediate post-war requirements of teaching and research in the United Kingdom, and especially to enable academic studies to be re-started and re-staffed on a scale sufficient to attract the research workers who had been drawn away during the War, the Foundation is now significantly broadening the scope of its benefactions. It has always recognized the importance of the universities in Britain being able to offer the fullest opportunities to postgraduate students from the British Commonwealth, but its own grants have been confined to research in Great Britain. In its fifth annual report for the year ending March 31, 1950*, the Nuffield Foundation indicates that it is now considering the possibility of encouraging research in some of the Dominion universities and associated institutions. It is pointed out that the help which the Foundation will be able to offer for research overseas is bound to be highly selective and limited in amount, and the first such grant for fundamental research overseas announced in this report is for £25,000 over ten years for the endowment of the Nuffield research chair of mechanical engineering in the New South Wales University of Technology. The chair is intended to enable the Nuffield professor to concentrate on new developments in the theory and practice of mechanical engineering and on the solution, through the medium of mechanical engineering, of some of the problems obstructing the full economic development of Australia.

The Foundation recognizes the important role of the universities of the British Commonwealth and the university colleges of the Colonies in training professional and technical leaders and in guiding and guarding the characteristic way of life and thought of the societies which they serve and help to mould; but the Foundation emphasizes that such work should receive recognition and encouragement from Great Britain. The strengthening of academic links throughout the Commonwealth may affect the growth and spread of all those other activities in which Britain should be lending its great and much-desired influence. Nevertheless, the new departure will not mean any slackening in the support given to work in Great Britain.

Grants promised during this first year of the second quinquennium amount to £506,925, to meet which £377,425 has been allocated from the income of the year, in addition to previous grants totalling £135,000. Of this, £38,725 is for research in rheumatism from the Oliver Bird Fund, with a promise of a further £31,500. For fundamental research, £46,750 has so far been given to biological and £33,000 to sociological studies, while £225,300 has been allocated from the income of the year towards fellowships, scholarships and similar awards, to be operated over the whole quinquennium, leaving £173,000 to be met from the remaining years; £60,000 is to be paid as the remainder of the Foundation's promised share in supporting the National Corporation for the Care of Old People. Miscellaneous grants totalling £19,300 include a further £16,000 to the Association of Universities of the British Commonwealth for travelling expenses in connexion with its annual meetings.

Grants in continuation of the past programme include, in the natural sciences, a new grant of £32,000 over a further three years, in termination of the original grant, to the Biomolecular Research Laboratory at Birkbeck College, London, where the studies envisaged include the investigation of the structure-types of the simpler compounds of biological importance, including those that might throw any light on protein and virus structure, and the systematic investigation of the low-molecular weight crystalline proteins and of crystalline viruses. The electronics department of the Laboratory is concentrating on the improvement of electronic and associated techniques and the investigation of the electronic properties of dielectrics and semi-conductors, while the electronic-computing section is attempting to reduce the time required for the laborious computations needed for crystal structures and to make possible computing of protein and virus work which could not be carried out at all by existing methods. For additional work on the physiology of learning at the Department of Anatomy, University College, London, an extra grant of £370 a year for two years has been made and £3,000 has been allotted to the inquiry into the fundamental principles that should be applied in shaping agricultural policy for Great Britain. A further grant of £2,000 over three years has been made towards the pilot surveys being

* Nuffield Foundation. Report for the Year ending 31 March, 1950. Pp. 86. (London: Nuffield Foundation, 1950.)

conducted for the Third Statistical Account of Scotland.

Grants from the Oliver Bird Fund, totalling £48,800, have been allocated for a programme of research on cortisone, the pituitary adreno-corticotrophic hormone and similar substances, as well as a further £8,825 for other researches into rheumatism. In this work the Foundation is maintaining the closest possible liaison with the Medical Research Council, and representatives of the pharmaceutical industry have been approached with a view to even wider collaboration, by pooling the results of commercial and academic research upon the problems presented by cortisone and adreno-corticotrophic hormone. This programme comprises a grant of £1,000 for apparatus and £10,000 over three years to the School of Biochemistry, Cambridge, for work on the isolation and purification of the pituitary adreno-corticotrophic hormone, its fission into peptides, and a study of their composition, structure and synthesis, as well as £5,000 over three years to the University Chemical Laboratory for research on the synthesis of biologically active related peptides and on the synthesis of compounds with cortisone-like activity. £10,000 for three years has been granted to the Dyson Perrins Laboratory, Oxford, for a project for the partial or total synthesis of cortisone and analogous substances, and £1,000 for two years to the School of Chemistry, Royal Technical College, Glasgow, for an investigation of materials other than bile-acids as a source of cortisone-like substances. The programme also provides: £800 a year for three years to the Rheumatism Research Centre, Manchester, for technical assistance in recording clinio-physiological data on the effect of cortisone and adreno-corticotrophic hormone; £5,000 over three years to the Department of Biomolecular Structure, Leeds, for intensive examination of arthritic lesions supplied by the Rheumatism Research Centre; and £10,000 over five years to the research unit to be set up by the Department of Medicine, St. Mary's Hospital School, London, for study of the action of cortisone and adreno-corticotrophic hormone on various other disease states.

New grants for fundamental research in the biological sciences include £8,250 over five years to the Department of Zoology, King's College, London, for the study of the differentiation between cell-types by nuclear and cytoplasmic transplantation, and by cytochemical methods; £10,000 to the Department of Anatomy, University College, London, for a five-year continuation of the research into the physiology of learning and the addition of an electronic engineer to the Department; £15,000 for five years to the Laboratory of Chemical Crystallography, University of Oxford, for the formation of a research unit equipped with calculating machinery and computing assistance for the X-ray analysis of crystals of complex compounds; and £12,000 over five years to the trustees of the Strangeways Research Laboratory, Cambridge, for research on the structure and physiology of living cells, with special reference to the problems of cell division, and experimental investigation into the processes of cellular differentiation.

In the sociological field, the Foundation has provided £6,000 for an inquiry over three years by the Department of Economics, Aberdeen, into the budgets of young childless couples, married couples having their first child and married couples having their second baby, as well as £12,000 over three years for a systematic research, in collaboration with the Tavistock Institute of Human Relations, on the development of various patterns of family life and the relative contribution of individuals and community to these patterns. A grant of £10,000 has been promised to the London School of Economics and Political Science to meet for five years staff salaries for the new Division of Research Techniques. The principal concern of the Division will be research in the application of statistical techniques to social data and the study of sampling and interviewing techniques. A grant of £5,000 has also been made to the joint mental-survey committee of the Population Investigation Committee and the Scottish Council for Research in Education to follow the careers of the 12,000 sample children for the five-year stage until they reach eighteen years of age.

For the first stage of an investigation into the consistency of stop-watch time studies, to be conducted with a steering committee under the chairmanship of Sir Frederic Bartlett, the Foundation has set aside £2,000. The dental fellowships and scholarships and the Dominion travelling fellowships schemes are continued unaltered, but a new scheme of United Kingdom medical fellowships has been instituted, under which the emphasis is changed to future teachers and research workers. A new scheme of travelling fellowships for the Home Civil Service has been introduced, under which three fellowships a year are offered to Civil servants at the principal and assistant-secretary levels—and equivalents in the scientific grades—to visit other parts of the British Commonwealth for six months to a year. The first selection took place in March 1950.

Finally, there is foreshadowed in the report a scheme for extending the Nuffield Foundation Dominion travelling-fellowships—already in operation for Australia, Canada, South Africa and New Zealand—to the new Dominions of Ceylon, India and Pakistan. Since the report was published it has been announced that the following awards have been made: Ceylon, one fellowship (in medicine); India, five fellowships (two in medical sciences, and one each in engineering, natural sciences, and social sciences); Pakistan, three fellowships (subjects not yet selected). The object of the travelling-fellowships, which are open to men and women graduates, is to advance the interests of the new Dominions and to strengthen further their academic ties with the United Kingdom. The fellowships last for one year, and, according to whether the holder is married or single, are worth £770–890, in addition to travelling expenses (for a wife as well) to and from Great Britain.

COTTON RESEARCH STATION, NAMULONGE, UGANDA

As announced in *Nature* of November 18 (p. 850), the Parnell Laboratories at the Empire Cotton Growing Corporation's new Cotton Research Station at Namulonge, near Kampala, Uganda, were officially opened by H.E. Sir John Hathorn Hall, Governor of Uganda, on November 9. Among the large gathering of guests who witnessed the ceremony were H.H. the Kabaka of Buganda and the Nabagereka, Sir John and Lady Russell, Dr. and Mrs. B. A. Keen, Dr. H. H. Storey, and Mr. G. W. Nye, representing the Secretary of State for the Colonies. Mr. F. R. Parnell, the first director of the Station, and Mrs. Parnell

were present, and also Mr. Arrowsmith, of the Raw Cotton Commission, Mr. Killick, of the Cotton Board, the directors of agriculture or their representatives from Kenya, Nyasaland, Tanganyika and Uganda, the director of agriculture and the chief of the Research Division from the Sudan, representatives from the Belgian Congo and French territories in Africa, and senior research officers of the Corporation from the Sudan, Tanganyika and Nyasaland.

The Namulonge Station, the director of which is Dr. J. B. Hutchinson, comprises 2,240 acres of land, excellently situated for experimental work on cotton and the food crops associated with it in the Buganda agricultural system. Ten staff houses and a guest house have been completed and occupied, and three more are in course of construction. The laboratory block was named by H.E. the Governor after Mr. F. R. Parnell, the first director. The building is designed to accommodate twelve research officers and to provide facilities for visiting workers and research students.

The day following the official opening was devoted to technical discussions and tours of the field experiments. In the afternoon, the first meeting of the African Advisory Board of the Station was held and was attended by directors of agriculture and senior research officers from Kenya, Tanganyika, Nyasaland, Uganda and the Sudan. The first progress report of the station was received, and the research programme discussed.

Research is planned in crop husbandry and physiology, entomology, plant pathology and plant breeding and genetics. Crop husbandry work will be concerned primarily with the task of fitting cotton into a balanced farming system, in which native food crops, grass-resting leys, and stock keeping will all have their place. Cotton physiology studies will start from a consideration of the crop environment, and comprehensive meteorological data are being collected. Work on the effect of water and nutrient supply and of leaf area on plant development and cropping capacity will follow, and will be linked up with studies on the physiology of lint development, and the genetic and environmental control of cotton quality.

The entomological programme includes studies of the bionomics of cotton pests, fundamental investigations in insect physiology, and work on the technique of pest control by insecticides. This last will be carried out jointly with the East African Agricultural and Forestry Research Organization.

The main problems in plant pathology are those of the epidemiology of bacterial blight, and of wilt diseases. The practical solution to both types of disease lies in the breeding of resistant varieties; but progress in breeding work will be slow and uncertain until the factors governing outbreaks of disease are understood, and the physiology of resistance has been elucidated.

Plant-breeding work includes the breeding and first multiplication of pedigree stocks of the commercial Uganda variety *BP*52, the transfer of genes conferring resistance to bacterial blight to East African commercial stocks, and the synthesis of heavy-cropping stocks for further selection at territorial stations.

Long-range genetical research is carried on at Shambat, near Khartoum in the northern Sudan, by arrangement with the Sudan Government. The maintenance of the very extensive *C.R.S.* collection of the world's cottons, and of wild species of *Gossypium*, is easier under the irrigated conditions of the northern Sudan than under rain-fed cropping in Uganda, and the possibility of growing two generations a year increases the rate of progress in genetic research.

At the meeting of the Advisory Board, discussion centred around the allocation of cotton research problems between territorial stations and Namulonge, and agreement was reached on general principles, and on detailed arrangements as they affect the Namulonge programme for the coming year.

NEW AUSTRALIAN HOUSE AT KEW

THE flora of Australia is certainly one of the most interesting and scientifically important floras of the world. It is naturally an extensive one, though when George Bentham produced at Kew the "Flora Australiensis" between the years 1863 and 1878, its seven volumes contained descriptions of less than nine thousand species of vascular plants, a number far exceeded by the known flora of to-day. For example, in the genus *Acacia* alone Bentham recorded 293 species compared with nearly twice that number now known to botanists. It is a flora notable for the rich representation of such families as Proteaceæ, Myrtaceæ and Rutaceæ and such genera as *Hibbertia* and *Drosera*, with a wealth of endemics that are fitting parallels to the marsupials and monotremes in their morphological interest and taxonomic isolation. The Australian flora includes species growing in a wide range of climatic conditions from the high rainfall areas of the south-west, where the giant blue gums grow to a height of more than three hundred feet, to the arid regions bordering on the Nullabor and central plains where vegetation may be said to flourish although it must endure an erratic rainfall that averages seven inches or less yearly. It is under these latter conditions that one encounters the amazing examples of homomorphy where species of many unrelated families appear remarkably alike until production of flowers discloses their individuality.

During the period of the Second World War, Captain and Mrs. McEacharn were forced to leave their famous garden, the Villa Taranto in Italy, when that country entered the War. They occupied the time of their enforced exile in Australia, where they collected seeds assiduously for the Royal Botanic Gardens, Kew. The outcome was a collection of several hundreds of species, including a very large number not previously in cultivation. The difficulty of growing many species from the Antipodes is notorious, especially in the early stages; nevertheless, plants of the majority have been successfully raised, including many Proteaceæ.

The very crowded conditions in the existing Temperate House at Kew, despite its large size, have necessitated further accommodation and a new house to provide for these valuable additions. Such is now in course of construction and it is expected to be completed by next June. It will be about ninety feet long by some fifty feet in width and will permit the growth of specimens in the central beds nearly thirty feet in height. By the use of aluminium it is hoped to ensure a more adequate illumination than the utilization of a timber framework permits.

Not only will the requisite new space thus be made available, but it will also be possible to achieve the segregation of the temperate species of the more arid environments from those which benefit by more humid conditions in a degree not previously possible.

When the present director of the Royal Botanic Gardens, Kew, was in Australia in 1949 and visited the various botanical centres in the Dominion, he found widespread interest and pleasure when the news of this project was made known, and this elicited spontaneous offers of further material. He brought back with him plants of the unique *Cephalotus follicularis*, which has pitcher leaves resembling those of *Nepenthes*, although the two families are in no degree related, and also specimens of that remarkable endemic Lycopodiaceous plant, *Phylloglossum drummondii*, which was found in a new locality.

The creation of a new post in the Herbarium, the occupant of which will be wholly concerned with the Australian flora, and the provision of this additional space for the culture of living material are important recognitions of the scientific significance of the vegetation of the Australian Commonwealth.

ROWETT RESEARCH INSTITUTE

EXTENSIONS TO BUILDINGS

IN 1945, Dr. D. P. Cuthbertson succeeded Sir John Orr, now Lord Boyd-Orr, as director of the Rowett Research Institute, near Aberdeen. During the War, the Institute's investigations into problems of animal nutrition were greatly curtailed, and the new director's first task was to plan a long-term programme of research in the light of new developments in science and the economic conditions of Great Britain.

Nutrition is a meeting ground of many scientific disciplines, and to decide which of these should be represented in the Institute posed a difficult selection. The choice was influenced by what was desirable and by the men and women who were willing to interest themselves in nutritional research. After five years of steady development, the Institute now includes the following departments or sections: physiology, agricultural chemistry, protein and carbohydrate chemistry, enzyme chemistry, microbiological chemistry, pathology, bacteriology, helminthology, animal behaviour, sheep husbandry, pig husbandry, dairy-cattle husbandry, statistics, radiology and photography. It shares an experimental farm of about a thousand acres with the North of Scotland College of Agriculture and the facilities of its Reid Library with the Commonwealth Bureau of Animal Nutrition. The scientific staff, which numbered nineteen in 1939, has increased to forty-nine. This growth required new laboratory accommodation and considerable adaptation of existing laboratories, animal houses and byres. In view of the shortage of building materials and labour, an ingenious compromise was made between the desirable and the attainable. Until a year ago the laboratories were accommodated in a building with a flat roof which was in need of extensive repairs. To deal with this situation, Mr. A. G. Ingham, chief architect of the Department of Agriculture for Scotland, produced an ingenious design for a new storey which would use the minimum of material, make the roof sound and provide new laboratories. This extension, now nearing completion, was formally opened on November 18 by Lord Strathcona and Mount Royal, an old friend and generous benefactor of the Institute.

During the same week-end the activities of the Institute as a social and collegiate centre were also furthered by the opening of a new wing of nine bedrooms, a much desired extension of Strathcona House, which is the residential club in the grounds of the Institute. The formal opening of this extension was also done by Lord Strathcona. As a recognition of Lord Strathcona's many services to the Institute, he was presented with his portrait in oils, painted by Sir Oswald Birley. These ceremonies coincided with the annual reception and dinner in honour of the founders of the Institute.

UNIVERSITY POPULATION OF GREAT BRITAIN

IN its fourth report for the session 1950, the Committee of Public Accounts returns to a point made by the Committee in its third report for the session 1948–49, referring to the possibility of some more effective means of securing adequate Parliamentary control over the large grant-in-aid to universities and colleges in Great Britain, which has risen from £1,680,000 in 1932–33 to £17,564,500 in 1949–50 and £23,284,150 for 1950–51. While in that report the Select Committee accepted the Treasury view that the grants need not be specifically authorized by statute and that it was not possible to present the estimates for the vote and the account in comparable form, it asked that the Treasury should consider whether, without impairing the independence of the universities, any further means could be adopted for informing Parliament how the grant-in-aid proposed in the estimate is to be spent.

In a minute of February 27, 1950, the Treasury referred to the publication of periodical reports by the University Grants Committee on university development, and of returns from the universities of financial and other statistics, and said that it was not clear what further steps could be taken to enable Parliament to judge of the wisdom with which the grants are used. Some support for this attitude is forthcoming from the publication of the "Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1948–49", recently issued*. When placed in comparison with the returns for the previous year, save in respect of Oxford and Cambridge, for which college incomes are excluded, the figures seem to supply reasonably adequate information. If this were supplemented, either in the returns or in reports from the University Grants Committee, by some more information about results obtained from certain of the larger non-recurrent earmarked grants for new developments, the substance of the Select Committee's criticism would seem to be met.

In justification of the Select Committee's observations, it must be recognized that, leaving out of account college income, even at Cambridge 46 per cent and at Oxford 51 per cent of the total income of the university came from Parliamentary grants. The Treasury, however, has undertaken, when the present quinquennium for which the grants have been allocated ends in July 1952 and before future arrangements are settled, to make a very close review in

* University Grants Committee. Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1948–49. Pp. 26. (London: H.M. Stationery Office, 1950.) 2s. net.

conjunction with the University Grants Committee of what has been achieved, and to examine in detail the question of possible extravagance. What must be avoided, however, is the sort of financial accountability which will endanger the originality and creative thought that the universities must safeguard at all costs and which would be a costly forfeit for saving a million or two of the taxpayers' money.

The income of the universities of Great Britain for the academic year 1948–49 amounted to £18,156,578, of which 6·7 per cent was represented by endowments, 1·9 per cent by donations and subscriptions, 5 per cent by grants from local authorities, 59·2 per cent by Parliamentary grants, and 20·6 per cent by fees. The total income for English universities was £14,588,360, of which £5,337,745 was for London, £1,664,926 for Cambridge, £1,332,674 for Oxford and £6,253,015 for provincial universities and colleges. The total income for Wales was £871,441 and for Scotland £2,696,777. Compared with the previous year, total income rose by £1,880,292, chiefly by increases of £1,338,923 in Parliamentary grants and £262,230 in fees, which now represent 59·2 per cent and 20·6 per cent, respectively, of the total income. Income from endowments increased by £18,166.

Of the total expenditure of £18,022,094, the sum of £323,305 represented allocations to reserve, and the remainder was distributed as follows: administration, 9·2 per cent; departmental maintenance, 66·3 per cent; maintenance of premises, 11·7 per cent; capital expenditure met from income, 2·2 per cent; other maintenance expenditure, 10·6 per cent, the largest item under the last head being again the cost of the ordinary university examinations. Library expenditure totalled £533,086 for England, £23,351 for Wales and £76,818 for Scotland, approximately 3·6 per cent of the total expenditure, an increase of £82,379 on the previous year. No university deviated appreciably from this percentage; although in some of the London institutions the percentage reached more than 30, the average for all London institutions was 3·4. Figures for the three technical institutions shown were much lower, although that of 0·6 per cent for the Imperial College of Science and Technology appears to be attributed to ready access to the Science Library at the Science Museum. Of the total expenditure on libraries, £340,298 is on account of salaries and wages, £162,091 on account of books and £64,774 for periodicals. Only seven universities, Oxford (£28,328), Cambridge (£10,425), Birmingham (£7,648), London (£6,674), Edinburgh (£6,524), Manchester (£6,257) and Leeds (£6,139) spent more than £5,000 on the purchase of books.

The full-time teaching staff increased from 6,536 to 7,390, and although the number of full-time students increased by 5,103 to 83,690, there is thus a welcome increase in the ratio of staff to students. The increase in staff was made up of 85 professors, 563 lecturers, and 17 assistant lecturers and demonstrators, with a decrease of 7 in the number of readers, assistant professors and independent lecturers. Of the students, while there were 5,237 more men, there were 54 fewer women; although there was an increase of 204 women in Scotland. These were distributed as follows: arts, 44·4 per cent; pure science, 19·2 per cent; medicine, 16·8 per cent; technology, 13 per cent; agriculture, 3·5 per cent; dentistry, 3·1 per cent. Of these 83,690 full-time students, 6,452 were engaged in research and other advanced work, 68,307 were reading for a first degree and 8,931 for a diploma; 61,554 were in England, 5,149 in Wales and 16,987 in Scotland, the English total comprising 15,082 at Oxford and Cambridge, 16,884 at London and 29,588 at provincial universities and colleges. Only at the University of Oxford was there a slight decrease in the number of full-time students. The proportion of full-time students residing in colleges and hostels was 22·7 per cent (18·9 per cent for men, 35·6 per cent for women), while 38·2 per cent were in lodgings and 39·1 per cent at home. Of overseas students from within the British Commonwealth, 3,335 were full-time and 1,492 part-time; a further 2,589 full-time and 1,162 part-time students came from foreign countries. Cambridge again took 669 and Oxford 693 of these full-time students, Edinburgh 498, the London School of Economics 413 and University College, London, 375. A total of 24,826 full-time students was admitted for the first time during the year, an increase of 1,319 on 1947–48. There was little change in the general outlines of the distribution during the year; but there were 2,006 more men and 76 fewer women in arts, 575 more men and 159 more women in medicine and dentistry, 1,609 more men but 54 fewer women in pure science, 763 more men and 25 fewer women in technology and 284 more men but 58 fewer women in agriculture. Of the full-time students, 73·7 per cent were receiving assistance from Government departments, local authorities, universities or other bodies during the year, the percentage for England as a whole being 76, for Wales 81·8 and for Scotland 62·9. For the provincial universities, the figure (78·8) was slightly less than for either Cambridge (79·8) or Oxford (81·7), but higher than in the University of London (66·7).

Of the 18,180 part-time students, 4,335 were engaged in research or other advanced work, 2,171 were reading for a first degree and 2,826 for a diploma. Of such students engaged in advanced work 45·8 per cent were in medicine (including dentistry), 30·7 per cent in pure science and mathematics, 12·6 per cent in technology and 0·7 per cent in agriculture, a distribution contrasting markedly with that for full-time advanced students of 37·6 per cent in pure science and mathematics, 9·1 per cent in medicine (including dentistry), and 3·1 per cent in agriculture, although the figure for technology (13·3 per cent) is similar.

SCIENTIFIC CO-ORDINATION IN THE SOUTH PACIFIC

THE welfare of the island peoples in the South Pacific has become the objective of a six-nation co-ordinated undertaking known as the South Pacific Commission. Recognizing the mutual nature of many of the problems in the areas they administer, Australia, France, the Netherlands, New Zealand, the United Kingdom and the United States have joined in organizing the Commission to ". . . encourage and strengthen international co-operation in promoting the economic and social welfare and advancement of the peoples of the non-self-governing territories of the South Pacific region. . . ." (*Science*, **3**; May 26, 1950).

A research council has been established as an integral part of the Commission. Four specialists have been engaged to devote their full time to the undertaking, and other specialists will be retained to implement specific needs.

Projects to further the aims of the Commission are proposed after research by the council experts. They

not only investigate the requirements of the area but also call on administrators and others who know the needs in the various territories to make recommendations; one of these suggestions led to the Seventh Pacific Science Congress which was held in New Zealand early in 1949. Council members are also guided by recommendations outlined by the commissioners representing member Governments. Proposals made for projects are submitted for final approval to the commissioners, who assemble for sessions twice a year. The four full-time members of the research council are assisted by a body of associate members; the full council meets annually to consider problems and needs of the South Pacific and to pass on projects to be submitted to the commissioners.

At the May 1949 session of the commissioners twenty-eight research projects in health, economic and social matters submitted by the research council were approved for action. Some of the projects are of an immediate nature; others will be developed on a long-term basis.

Financial support for the Commission comes from the member Governments, contributions to the annual budget being made as follows: Australia, 30 per cent; France, 12½ per cent; the Netherlands, 15 per cent; New Zealand, 15 per cent; the United Kingdom, 15 per cent; the United States, 12½ per cent. The budget for 1950 was slightly in excess of £144,000 sterling.

Technical assistance to the various territories in its area is of vital concern to the Commission. Although the organization is entirely separate from the United Nations, liaison is maintained with that body and such of its affiliated and subsidiary bodies as will have common concern in the South Pacific. This is particularly true in regard to the World Health Organization, the Food and Agriculture Organization, and the Indo-Pacific Fisheries Council. The South Pacific Commission is modelled on its successful prototype in the western hemisphere, the Caribbean Commission, several of the same member Governments being concerned.

ONTARIO RESEARCH FOUNDATION

ANNUAL REPORT FOR 1949

THE annual report for 1949 of the director of research of the Ontario Research Foundation* characterizes the year as one of transition to conditions which from an economic point of view are regarded as more normal. The fellowship work of the Foundation continued at a high level, though sometimes the absence of men and women with specialized postgraduate experience prevented the establishment of a new fellowship. The short-term work in the laboratories continued to grow, largely due to the work of the Department of Industrial Research Services, which was utilized by 1,910 different companies on 2,853 occasions, laboratory work being involved in about half of these. This assistance to the smaller industrialists is paid for by them on a reasonable basis of cost. A list of papers published during 1949 is appended, together with the balance sheet and statement of income and expenditure.

* Ontario Research Foundation. Annual Report for 1949. Pp. 24. (Toronto: Ontario Research Foundation, 1950.)

In the Department of Biochemistry progress is reported in the investigation of the chemistry of flavone reversion in linseed and other vegetable oils, of the effect of oxidation on the infra-red spectra of hydrogenated and unhydrogenated oils, and the formation of *trans* isomers of fatty acids during the polymerization of linseed oil. An X-ray method for the non-destructive testing of footwear used by the Armed Services has been devised, involving the use of treated thread which is clearly visible in a fluorescent screen, the thread being also made resistant to moulds by the treatment. A new laboratory was organized to study problems associated with the making of tomato products.

Considerable attention has been given to the organization of the laboratories in the Department of Chemistry which are responsible for short-term work. Investigations of the repair of methyl methacrylate dentures under the dental materials research fellowship have been concluded and the results published, while work on the use of methyl methacrylate for direct intra-oral fillings has been concerned mainly with methods for providing the localized heating necessary for polymerization *in situ*. Detailed reports have been made on the essential oils from the foliage of black spruce and hemlock trees, and considerable progress has been made in the study of the chemistry of white birch.

The Department of Engineering and Metallurgy has maintained basic research fellowship projects and short-term investigations at a high level, but has been obliged to reduce to a minimum purely routine service such as specialized heat treatment. The latest type of Bausch and Lomb metalloscope has been added to the equipment for metallography, and the Department has been asked to investigate possible methods of reducing coke consumption in Canadian blast furnaces by the use of electric smelting equipment. An investigation initiated into the non-destructive testing of metals has led to the discovery that failure can be predicted long before it occurs by tracing the changes in the magnetic properties of steel parts.

In the Department of Parasitology the work on the protozoan blood parasites of birds has been almost entirely confined to the species occurring in wild ducks. The work on *Ascaris lumbricoides* has been directed towards isolating a substance which will protect against infection. Preliminary investigations have been made of the conditions responsible for 'swimmers' itch' or cercarid dermatitis, which has a wide but irregular distribution. The Department of Physiography has been concerned chiefly with details associated with the publication of the physiographical map of southern Ontario and the accompanying monograph.

In the field of textiles, the fellowship sponsored by Courtaulds (Canada), Ltd., has completed a thorough study of statistical methods for determining the sizes of women's garments and has investigated the density, swelling and regain of viscose rayon yarns. The York Knitting Mills fellowship has been concerned chiefly with designing and assembling the equipment for a fundamental study of principles involved in the commercial production of worsted yarn, and the Canadian Industries, Ltd., nylon fellowship has been devoted to a study of those properties of the nylon fibre which determine the commercial properties of the finished fabric. Some independent work has been commenced on the elastic properties of textile fibres, for which purpose nylon is being investigated first.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Origin of the Moon

THE resonance theory of the origin of the moon was reduced to a state of low probability by work of Jeffreys[1] in 1930. The calculations of Jeffreys were based on the assumption of a velocity of slip between the central core and mantle of the primitive earth – moon body, and implied that energy would be dissipated at the core boundary several hundred times faster than could be allowed if the needed amplitudes were to be developed through resonance.

Recent work[2,3], however, suggests that certain aspects of the resonance theory may well be re-examined in the light of the hypothesis that the discontinuity in density between the earth's mantle and central core is caused primarily by pressure rather than by change of material from ultrabasic rock to nickel–iron. In these circumstances, there would not be a slip-velocity over the boundary in the form assumed by Jeffreys. There would, of course, still be dissipation of energy at the boundary as the density changed suddenly in the process of adaptation to the strained configuration arising during resonance, and it is practically certain that this dissipation would still be sufficient to stop the birth of a moon by the direct resonance process. But a new calculation of the amount is desirable.

The recent work mentioned has, however, further implications. Ramsey[3] has shown that if the existence of a core in a planet is due primarily to pressure instead of chemical change, then a planet with a relatively small core would be gravitationally unstable. Ramsey[4] considers that not only is the density change at the outer boundary of the earth's core a transition caused by pressure, but also that the phenomenon is repeated at the boundary of the inner core. Other work[5] favours (slightly) the contrary hypothesis that the inner core, though not the rest of the central core, is chemically distinct from the mantle. One possible way of reconciling the two views is to suppose that a second transition, instead of being responsible for the earth's present inner core, would have been associated with a further discontinuity surface once present in the earth, but since removed. This provides the basis for a new theory of the moon's origin.

The theory I wish to propose is that, inside the central core of a primitive earth – moon body, there was an additional high-density region, no longer present in the earth, caused by pressure, and in such proportion that the body was near a state of instability. Resonance would now be called upon to fill the role of partial rather than full responsibility for the disruption which led to the birth of the moon. The idea would be that resonance would, so to speak, first act as a trigger effect to take the primitive body through a potential barrier and so lead to instability. The gravitational energy thereby made accessible might then possibly be sufficient to result in the ejection of the moon; but even if it were not sufficient, resonance would still be available in conjunction with the changes of gravitational energy to supply additional energy for the purpose.

It may be remarked that, suitably modified, the theory can be made independent of differences between views of the nature of the present earth's inner core. For example, if the inner core proves to be actually due to a second transition caused by pressure, then the theory might envisage a third such transition inside the primitive body. In fact, it is possible, until quantitative checks have been made, to suggest several minor variations of the theory.

Ramsey (in a paper in course of publication, kindly sent to me) has given some attention to the question of the origin of meteorites and the asteroids, and estimates that, for the case of a planet with a single homogeneous small core, the energy that could be released through instability would correspond to the ejection of a quantity of matter somewhat more than 0·001 of the mass of the earth. The new theory here proposed for the origin of the moon will be quantitatively satisfactory if this factor 0·001 can be raised to the order of 0·01.

Several auxiliary investigations are necessary to test how far the factor can be raised. These include: (i) the extension of Ramsey's calculations to the more complicated type of central core envisaged in the theory here presented; (ii) investigations of instabilities in relation to the distorted configurations that would be brought about through resonance; (iii) estimates of rates of energy dissipation due to all causes.

Some parts of the needed investigations depend on data on the earth's interior which are not as yet available, and in other parts there are mathematical difficulties. Thus it may be some time before this new theory can be put on a precise quantitative footing. But, in the meantime, it seems that some of the implications of the resonance theory of the origin of the moon in geology and geophysics should receive more attention than has been the case over the past twenty years.

K. E. BULLEN

Department of Mathematics,
University of Sydney. Oct. 10.

[1] Jeffreys, H., *Mon. Not. Roy. Ast. Soc.*, **1**, 169 (1930).
[2] Ramsey, W. H., *Mon. Not. Roy. Ast. Soc.*, **108**, 406 (1948).
[3] Bullen, K. E., *Mon. Not. Roy. Ast. Soc.*, **109**, 457 (1949).
[4] Ramsey, W. H., *Mon. Not. Roy. Ast. Soc., Geophys. Supp.*, **5**, 409 (1949); *ibid.*, **6**, 42 (1950).
[5] Bullen, K. E., *Mon. Not. Roy. Ast. Soc.*, **109**, 688 (1949); *ibid., Geophys. Supp.*, **6**, 50 (1950).

An Analogue Multiplier

IN practically all analogue computer work there seems to arise the problem of multiplying two time-varying voltages. There are quite a number of methods of performing this multiplication and some of them fulfil the requirements of general analogue machines: (1) preservation of sign; (2) frequency response at least as good as other components in the machine; (3) voltage-levels high and output impedance low; (4) error having a maximum of 0·1–1·0 per cent.

The problem of multiplier design is somewhat more difficult if to the above requirements are added the following ones: few, if any, unusual techniques, critical voltages or high-precision or rare equipment required; small consumption of power, and the unit to be small and inexpensive enough so that several may be used.

There are several identities that facilitate electronic multiplication. The one used herein is:

$$xy = \frac{(x+y)^2 - (x-y)^2}{4},$$

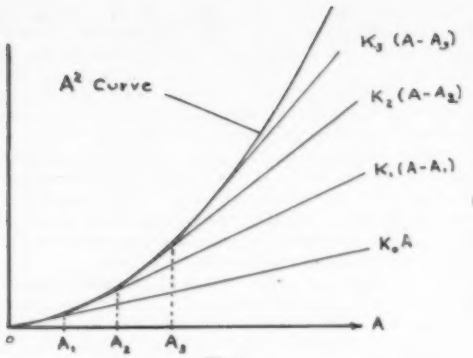

Fig. 1

which retains its sign in spite of the squaring process. Also it converts a function of two variables into a pair of functions of one variable voltage each. The three additions (subtractions) are easily performed, as is the division by 4, but the square law devices require more consideration. Fortunately there exists a technique for squaring a voltage that does not depend upon the square-law characteristic of a vacuum tube and the like, and which can, with additional equipment, be made as accurate as one wishes. This is the method of straight line curve approximation with clipping diodes, which works particularly well with monotonic curves. Fig. 1 shows the lines used to approximate to the square-law curve. The voltage A is either one of the terms in the identity given earlier. For different ranges of the voltage A, the approximating curve is:

$O\ A\ A_1$ output voltage K_0A
$A_2\ A\ A_3$,, ,, $K_0A + K_1(A-A_1)$
$A_2\ A\ A_3$,, ,, $K_0A + K_1(A-A_1) + K_2(A-A_2)$, etc.

As shown in Fig. 2, the portions of A, that is, K_0A, K_1A, etc., are taken from a voltage divider network. These are fed to a diode clipping circuit, the clipping voltages being K_1A_1, K_2A_2, etc. The output of the clipping circuit will be:

the clipping voltage, K_nA_n, if $K_nA = K_nA_n$,
or the diode input voltage, K_nA, if $K_nA = K_nA_n$,

which is one term of the 'expansion' given above provided K_nA_n is subtracted. Fortunately, for a square-law curve all of the K_n's are equal and the A_n's are at equal intervals. Using this technique, it is possible to approximate to the square-law curve

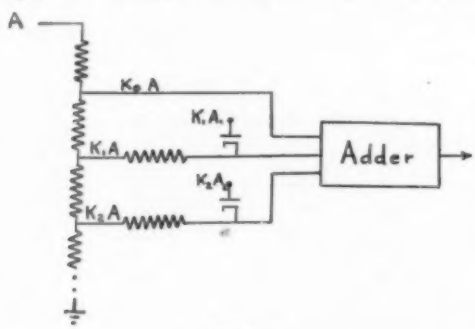

Fig. 2

from zero to 100 volts with only eleven crystal diodes with a maximum error of 0·1 volt. To cover negative values of the argument, another set of eleven is required.

It might at first seem that the 0·1-volt error would be a large percentage error when operating in the region near zero. However, two square terms are being subtracted and the error in the final product is, with the exception of a very small range of values, considerably less than one per cent. Such a multiplier has been built and has operated very satisfactorily. Aside from the diodes and resistors used in the approximating circuit, the multiplier contains four adding amplifiers, the whole unit being mounted on a chassis 11 in. × 14 in. It seems to fulfil all the requirements given in the first paragraph. Its response time is limited mainly by the amplifiers and may be made better than the computer itself. Even though components were not particularly selected, the maximum error was better than expected and well below one per cent.

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Temperature Stresses in Irregular Solids

Hitherto it has not been possible to express temperature stresses in a form capable of numerical solution, in an axially symmetrical body of irregular shape in which temperature variations occur in both the radial and axial directions. Such conditions are present in solid rotors of turbines, a problem which has been the subject of study here and elsewhere. The three points of difficulty were: (1) irregular boundaries, (2) temperature gradients in two directions at right angles, and (3) transient state of temperature distribution. Stress functions suitable for use with the relaxation technique could not be found where those conditions held.

The difficulties have now been overcome, and a convergent numerical solution can be obtained by using stress functions X and Ψ, where

$$I^2X = 0, \text{ and } \frac{\partial^2 X}{\partial z^2} = I^2\Psi + \frac{r}{1-\sigma}\frac{\partial}{\partial r}(EkT)$$

throughout any axially symmetrical system, I^2 being the operator, $\left(\frac{\partial}{\partial r^2} - \frac{1}{r}\frac{\partial}{\partial r} + \frac{\partial^2}{\partial z^2}\right)$.

In that case the boundary conditions are: $\Psi = 0$, and

$$\left(\frac{1-\sigma}{r^2}X - \frac{1}{r}\frac{\partial X}{\partial r} - \frac{1}{r}\frac{\partial \Psi}{\partial r} - \frac{EkT}{1-\sigma}\right)\cos(rv) - \frac{1}{r}\frac{\partial \Psi}{\partial z}\sin(rv) = 0;$$

the temperature stresses being as follow:

$$\text{Shear stress} = -\frac{1}{r}\frac{\partial \Psi}{\partial z}. \qquad \text{Axial stress} = \frac{1}{r}\frac{\partial \Psi}{\partial r}.$$

$$\text{Radial stress} = \frac{\Psi + (1-\sigma)X}{r^2} - \frac{1}{r}\frac{\partial}{\partial r}(\Psi + X) - \frac{EkT}{1-\sigma}.$$

$$\text{Hoop stress} = -\frac{\Psi + (1-\sigma)X}{r^2} - \frac{\sigma}{r}\frac{\partial X}{\partial r} - \frac{EkT}{1-\sigma}.$$

(In the above expressions r and z are radial and axial directions respectively, σ is Poisson's ratio, v is the direction at right angles to the boundary,

E is Young's Modulus, k the coefficient of linear expansion, and T temperature.)

These boundary conditions are quite satisfactory for use with the relaxation technique even if the boundaries are very irregular, and a convergent numerical solution is now nearing completion. The thermal stresses can thus be found for any known axially symmetrical state of temperature distribution, varying radially and axially, whether it be transient or steady.

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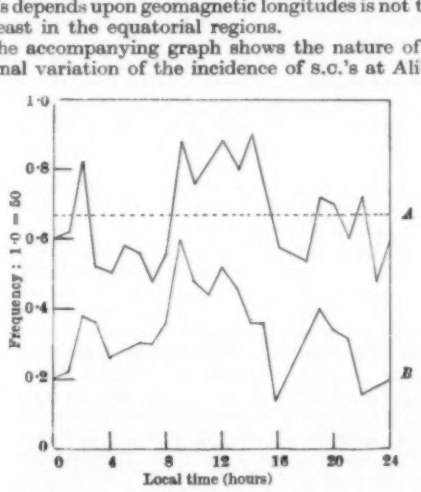
Sept. 15.

'Sudden Commencements' in Geomagnetic Field Variations

A study of the phenomenon of 'sudden commencements' in geomagnetic field variations has been made by Newton[1] and also recently by Ferraro and Parkinson[2], but the observations analysed are insufficient to ascribe definite cause and characteristics to this phenomenon. The records of Alibag Observatory ($\varphi = 18{\cdot}6$, $\lambda = 72{\cdot}9$) over the period 1905–44 have been analysed to provide further data. The first type of s.c., characterized by a rise in H and a fall in V, is very prominent in the Alibag records and can be picked up without any difficulty. The second type described by Ferraro and Parkinson, where the increase in H is preceded by a small movement in the opposite direction, is *absent* from the Alibag records. The third type, called the 'inverted s.c.'s', does occur at Alibag, but their frequency is small. It is quite possible that they are not really s.c.'s but form part of normal fluctuations. Altogether, about 800 s.c.'s were recorded during the period under review, of which only 28 can be classified as 'inverted s.c.'s'. In order to fit the curve suggested by Ferraro and Parkinson, the number of s.c.'s of the second type at Alibag (geomagnetic longitude 143·6°) during the period under discussion should have been about 200 instead of the actual figure, 0. This difference is certainly beyond all limits of statistical error and must be a real one. It shows that the suggestion made that the second type of s.c.'s depends upon geomagnetic longitudes is not true, at least in the equatorial regions.

The accompanying graph shows the nature of the diurnal variation of the incidence of s.c.'s at Alibag,



for all s.c.'s (curve A) and for those only which are followed by large or moderate disturbances (curve B). They show that there is a minimum between 4h. and 7h. local mean time and again at about 17h. L.M.T., but a maximum between 9h. and 13h. is more prominent. It is interesting to note that whereas the minima are more pronounced at Greenwich, the maximum is more pronounced at Alibag; and at stations of intermediate latitudes neither of them is pronounced and the frequency curve exhibits no special feature. It may be pointed out here that some of the s.c.'s recorded at one observatory have not been recorded at another observatory. I have given in Table 1 a list of s.c.'s which were recorded very prominently at Alibag but were not recorded at Abinger, and in Table 2 a list of s.c.'s recorded at Abinger but not at Alibag. They show that, although the s.c.'s are possibly a world-wide phenomenon, the data analysed at different observatories are not uniform and are influenced by local effects.

Table 1. Sudden Commencements at Alibag but not at Abinger

Date	Time U.T. h. m.	ΔH for main impulse (γ)	Date	Time U.T. h. m.	ΔH for main impulse (γ)
1939			1941		
April 23	5 47	84	June 9	9 14	31
1940			Sept. 18	4 14	24
March 23	6 18	40	Dec. 1	6 00	35
1941			1942		
March 1	5 22	70	March 5	15 22	35
March 30	16 38	44			

Table 2. Sudden Commencements at Abinger not Recorded at Alibag

Date	Time U.T. h. m.	Date	Time U.T. h. m.	Date	Time U.T. h. m.
1939		1941		1944	
April 19	7 38	July 22	22 56	May 16	12 46
1940		1943		Dec. 16	0 28
April 1	16 8	Feb. 16	20 56		
Aug. 26	2 56	Aug. 28	12 56		

The above lists are only a few of the types they represent and have been given so that other observatory records may be examined for these cases to find out, if possible, the nature of the geographical distribution of the s.c.'s which is essential in locating the origin of this interesting type of geomagnetic fluctuation.

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Howrah. Sept. 2.

[1] Newton, H. W., *Mon. Not. Roy. Ast. Soc., Geophys. Supp.*, **5**, 159 (1948).
[2] Ferraro, V. C. A., and Parkinson, W. C., *Nature*, **165**, 243 (1950).

Mechanisms of Excitation of the $C^3\Pi_u$ State of Molecular Nitrogen

It has been suggested in a previous communication[1] that the mechanism involved in exciting the triplet-levels of molecular nitrogen by electron collision in gaseous electrical discharge, or controlled electron sources, is not, as has been previously assumed, a direct excitation from the lowest vibrational level of the triplet state concerned, but rather an indirect process in which the levels of an upper singlet state (either $a^1\Pi_g$, or one of a group of states between 12 and 15 volts above $X^1\Sigma_g^+$ called 'b' in ref. 1) are

first excited. Then a second process, presumably a collision of the second kind between the molecule in the excited singlet state and a slow electron, results in a transition to the vibrational level of the triplet state concerned.

The particular case of excitation of vibrational levels of the $C^3\Pi_u$ state followed by the subsequent emission of the second positive band system ($C^3\Pi_u \rightarrow B^3\Pi_g$), has been analysed from a kinetic point of view upon the assumption of (i) a direct excitation process ($X^1\Sigma_g^+ \rightarrow C^3\Pi_u$) and (ii) an indirect excitation process $X^1\Sigma_g^+ \rightarrow b \rightarrow C^3\Pi_u$. Comparison of the resulting final equations, of which more complete details will be published shortly, with experimental results, indicates which of the excitation mechanisms is the more probable. It is this comparison which is here presented.

After considerable simplification, the result of the kinetic analysis of both mechanisms is an equation of the form :

$$\log\left(\frac{I_{CB}}{n_e}\right) = \text{const.} - \frac{\alpha}{T},$$

where I_{CB} is the integrated intensity of a particular band of the second positive system excited in a region of a discharge plasma where the electron concentration is n_e and electron temperature is T. $\alpha = \frac{eE_{XC}}{k}$ for the direct mechanism and $\frac{eE_{Xb}}{k}$ for the indirect mechanism, where E_{XC} is the energy separation between $X^1\Sigma_g^+$ and $C^3\Pi_u$—about 11 volts—and E_{Xb} is the energy separation between $X^1\Sigma_g^+$ and 'b'—about 14 volts ; e and k have their usual significance.

Experiments have been performed, using a simple D.C. glow discharge in nitrogen as a source of radiation, in which n_e and T can be measured electrically. The discharge plasma when focused upon a spectrograph slit allows the second positive band system to be photographed and hence the integrated intensities I_{CB} can be measured. Preliminary results for four of the bands of the second positive system are given in the accompanying table.

Band	α	E (electron volts)
(0, 0)	15·4	13·1
(0, 2)	20·1	17·3
(1, 3)	21·6	18·5
(2, 4)	16·5	14·2

It is evident that although no great accuracy at the moment is claimed for the results, they indicate that the energy E involved in excitation of the $C^3\Pi_u$ state is of the order of the separation between the levels 'b' and $X^1\Sigma_g^+$ rather than between the level $C^3\Pi_u$ and $X^1\Sigma_g^+$. This suggests, therefore, that the indirect mechanism of excitation of the triplet levels is more probable than the direct mechanism, at least in so far as glow discharges are concerned. Work is continuing on these and other aspects of the method, to increase the accuracy and to obtain data upon other bands.

I wish to thank the National Research Council of Canada for interest in, and support of, this and an allied project.

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Two-Body Nuclear Interaction, consistent, within the Limits of a Single Configuration, with the Spin and Magnetic Moment of the Ground-States of Lithium-6, Boron-10 and Lithium-7

The matrix elements of a nuclear interaction of the following kind :

$$V_{12} = (V_c C_{12} + V_t S_{12} + V_s M_{12})\varphi(r),$$

with

$$C_{12} = (\vec{\tau}_1 \cdot \vec{\tau}_2)\ \{1/10 + 7/30\ (\vec{\sigma}_1 \cdot \vec{\sigma}_2)\}, \quad \text{(ref. 1)}$$

$$S_{12} = \frac{3(\vec{r} \cdot \vec{\sigma}_1)(\vec{r} \cdot \vec{\sigma}_2)}{r^2} - (\vec{\sigma} \cdot \vec{\sigma}_2),$$

$$M_{12} = \{(\vec{\sigma}_1 + \vec{\sigma}_2) \cdot [\vec{r}\,\vec{p}]\},$$

$$\vec{r} = \vec{r}_1 - \vec{r}_2,\ \vec{p} = \vec{p}_1 - \vec{p}_2,\ r = |\vec{r}_1 - \vec{r}_2|,\ \varphi(r) = \frac{e^{-r/a}}{r/a},$$

$$a = 1{\cdot}35 \times 10^{-13}\ \text{cm.},$$

have been evaluated for the levels arising from the nuclear $s^4p^2(^6\text{Li})$, $s^4p^3(^7\text{Li})$ configurations and for the levels of maximum orbital symmetry (partition numbers [42]) of the $s^4p^6(^{10}\text{B})$ configuration, using oscillator wave functions. Using the measured magnetic moment of lithium-6 to determine the $S-D$ admixture in its ground-state (neglecting, however, the contribution[2] of M_{12} to this moment), a relationship between V_c, V_t, V_s, is deduced for the consistency with spin 1 for the ground-state of lithium-6. It is found then that there still remains a range of possible values of V_c, V_t, V_s consistent with the spins for the ground-states of both lithium-7 and boron-10 (3/2 and 3 respectively).

Taking $V_t = 1{\cdot}87\ V_c$, $V_s = -0{\cdot}34\ V_c$, V_c positive (values within this small range), one obtains, also, agreement with the magnetic moments of boron-10 and lithium-7, again neglecting the contribution to these moments due to M_{12}. It is to be noted that this interaction involves a tensor force of the opposite sign to that usually assumed, although it is not necessarily excluded by experiment[3]. No agreement could be obtained with a tensor force of opposite sign, nor with a charged or charge symmetric spin-orbit interaction, although the tensor force may be charged or charge-symmetric. The central force can also be modified considerably without affecting the result ; for example, it could be neutral or charged. The measured positive quadrupole moment of lithium-7 could not be accounted for.

Since the calculations of Present and Feenberg[4] show that by considering inter-configurational mixing, a positive quadrupole moment of lithium-7 may be achieved with purely central forces, it is clearly necessary to extend the above calculations to include inter-configurational mixing before definite conclusions are reached, although appreciable amounts of spin-orbit and tensor force interactions are indicated. It would also appear desirable to investigate whether, with an appreciable spin-orbit interaction present, the deuteron and scattering data are consistent with a tensor force of opposite sign.

A detailed description of the method, which makes use of the fractional parentage coefficient method developed by Racah[6], will be published elsewhere.

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A Non-Parametric Method of Testing *k* Samples

Pitman[1], Wald and Wolfowitz[2], Dixon[3] and others have suggested non-parametric methods for testing the null-hypothesis of two samples. Recently, I have used[4] similar methods for testing k samples. The object of the present communication is to show that S of Kendall's[5] τ for rank correlation can be used in testing the null-hypothesis of k samples from univariate populations.

Suppose there are k samples of sizes $n_1, n_2, \ldots n_k$ such that $\sum_1^k n_r = n$. Assume that all the observations are different. Let $S_{n_1}, S_{n_2}, \ldots S_{n_k}$ be the values of S for the k samples. Also let S_n be the value of S for the k samples arranged in a sequence (that is, the samples are put in the order 1, 2, . . . k as presented for examination). It can be shown that

$$z = \frac{S_n - \sum_1^k S_{n_r}}{\sqrt{v_n - \sum_1^k v_{n_r}}}$$

(where v stands for the expected variance of S) tends to be distributed normally as n tends to infinity.

This finding can obviously be used for testing the null-hypothesis of k samples. It can also be extended for examining the data of randomized block and Latin square lay-outs.

Full details will be published in the *Journal of the Indian Society of Agricultural Statistics.*

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Bursting Bacteria by Release of Gas Pressure

Many investigations of bacterial metabolism require that the contents of the cell be released. This apparently simple requirement has not yet been met in a completely satisfactory way. The present method differs in principle from previous techniques. It consists of sudden release of applied gas pressure and is very simple, rapid and inexpensive. Under optimum conditions, bursting of well over 90 per cent of the cells is easily attained, and the only substance introduced is a gas which has been shown to be non-injurious to the bacteria.

In the present experiment, aviator's oxygen-breathing bottles (surplus), 3,000 lb./in.² test, 350 ml. capacity (the small type for parachute jumps), were modified for use. There is now available in a variety of sizes a very similar inexpensive bomb constructed of stainless steel and rated at 1,800 lb./in.² (Hoke, Inc., Englewood, N.J.).

Before introducing the bacteria, the tank is sterilized by rinsing with water and then autoclaving. In the present experiments the bomb was kept in a bath at 37–38°. The gas, for example, nitrous oxide, is forced into the tank over the course of a half to one minute (to minimize the effect of heating due to the compression of the gas) until the pressure is about 500 lb./in.². The apparatus is then shaken a few times and allowed to stand for about three minutes. The pressure regulator is closed, the bomb inverted over a beaker or flask, shaken, and the culture expelled *as rapidly as possible*. The excess gas is then bled out slowly to avoid unnecessary dissemination of bacterial spray. This entire operation requires less than five minutes. If greater breakage is desired, the bomb may be evacuated and the culture put through more cycles of the same treatment.

The efficiency of the procedure was tested by agar plate (viable) counts and by direct microscopic observation of unstained bacteria with the Petroff–Hauser counting chamber.

Bacterial cells are so small that it is most difficult to secure substantial breakage by mechanical methods without such intensive localized friction that heating effects ensue with concomitant likelihood of enzyme denaturation. In the present method, actual breaking action comes, presumably, from the expansion of gas within the bacterial cell and hence involves cooling rather than heating; chilled cultures will, in fact, freeze on being expelled. The gas introduced does not injure the bacteria so far as has been observed. Preliminary experiments indicate the retention of formic dehydrogenase enzymatic activity (I wish to thank Dr. Arthur B. Pardee for these determinations), but show destruction of bacteriophage. Obviously the method would require adaptation for pathogenic organisms, since considerable spray is produced. The present experiments were confined to *Escherichia coli* strain *B* grown with aeration in a synthetic (glycerol, 'Casamino acids') medium.

The gas used for this method of bursting should be as inert as possible. With carbon dioxide the bursting was successful, but viable counts were always much lower than Petroff–Hauser direct counts, possibly

Table 1. Direct Microscopic and Viable Count of *E. coli* burst by Various Gases

Gas	Pressure	Starting concentration (cells/ml.)	% Burst (Petroff–Hauser count)	% Rendered non-viable
Nitrogen	900	$1{\cdot}5 \times 10^8$	75	72
Nitrous oxide	500	$1{\cdot}0 \times 10^8$	54	43
	500	$2{\cdot}0 \times 10^8$	61	75
	500	$9{\cdot}2 \times 10^7$	78	76
	500	$2{\cdot}2 \times 10^8$	64	81
Carbon dioxide	500	$1{\cdot}5 \times 10^8$	56	99
	500	$2{\cdot}1 \times 10^8$	57	95
	500	$2{\cdot}5 \times 10^8$	48	96

because the acidity produced in the solution by this gas under 500 lb./in.². pressure may have killed a considerable percentage of the bacteria. Using nitrous oxide and nitrogen, however, the plate count (viable count) parallels the microscopic count, that is, no intact cells are non-viable (Table 1). Moreover, it was found that when the culture is released slowly, the bacteria are recovered nearly intact by both viable and Petroff–Hauser counts. Nitrous oxide was ineffective at 250 lb. pressure, but satisfactory at 500–800 lb. The same effect was observed with argon and nitrogen, which require pressures of 900 lb. or more for bursting (Table 2). It is thought that the relative inefficiency of these gases may be related to their low solubility.

Table 2. Bursting of *E. coli* with Various Gases
The figures represent the range observed in two or more experiments under the same conditions (20-ml. sample in bomb 3 min.).

Gas	Pressure	Starting concentration (cells/ml.)	% Burst (Petroff–Hauser count)
Argon	500	$3{\cdot}0–4{\cdot}5 \times 10^8$	0–7
	900	$2{\cdot}8–6{\cdot}0 \times 10^8$	30–46
Nitrogen	500	$2{\cdot}8–3{\cdot}3 \times 10^8$	14–20
	900	$1{\cdot}1–1{\cdot}5 \times 10^8$	75
Nitrous oxide	250	$1{\cdot}0–1{\cdot}9 \times 10^8$	0–5
	500	$1{\cdot}0–2{\cdot}2 \times 10^8$	54–78
	750	$1{\cdot}1 \times 10^8$	53–56
Carbon dioxide	500	$1{\cdot}5–2{\cdot}5 \times 10^8$	48–56

Considerable investigation of the range of conditions has shown that by far the most important factor is the speed with which the culture is released. The best results were obtained when the culture was released as rapidly as was consistent with the recovery of the sample. Expelling the culture through fine orifices (0·0135 in. and 0·004 in. diameter) gave no substantial breakage.

In a bomb of volume 350 ml. it has been found that the efficiency drops markedly with sample volumes greater than 50 ml.

The experiments were done usually at a bacterial concentration of 10^8/ml. For most purposes, it is customary to raise bacteria to saturation—that is, a 24-hr. culture. When such resting phase *coli* were used, however, the breaking by gas release was in every case highly inefficient. For the present it seems that the bacteria should be harvested just before the end of logarithmic growth, that is, *c.* 10^9 under present conditions. Results of several successive bursts indicate that with 10^9 bacteria/ml., greater than 90 per cent breakage can be secured in two bursts, and even higher percentages of breakage can be obtained by further bursting cycles. Post-logarithmic (24-hr.) cultures showed very poor initial bursting and the percentage was not improved appreciably by repeated cycles. Cells concentrated by centrifugation are burst, but less efficiently than log-phase cultures.

Recoveries even of small samples (10–20 ml.) are surprisingly good considering the nature of the process. Despite the apparent amount of spray produced, usually only 3–4 ml. were lost.

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Significance of 'Fungus Gardens' in Termite Nests

The significance of the 'fungus gardens' found in the nests of termites of the family Termitidæ is uncertain. It has been supposed that the fungi are used as food; but Grassé[1] has shown that the conidia and the mycelium cannot be of great food value for a big colony, although the presence of the remains of conidia in the alimentary canal proves that they are sometimes eaten by the workers. The 'fungus gardens' may also take part in maintaining a suitable humidity[2]. In those species in which the brood is found in the 'fungus gardens', it has been thought that the 'gardens' form a suitable milieu for the delicate larvæ. But as the brood may also be found (sometimes in the same species) elsewhere in the nest, this function has not been clearly demonstrated. The following observations made during an expedition of the Swiss Tropical Institute to East Africa in 1949 may throw new light on this problem.

Role of the fungi as food. Although the conidia are undoubtedly eaten (see above), it appears that workers have never been observed in the act of consuming them. The shape of the typical spherical conidia ('cauliflowers') was formerly supposed to be dependent upon the termite activity, but it is now clear that *Termitomyces* also produces the same conidia in artificial culture[3]. Using a method recently described[4], it was possible to keep a colony of about two thousand individuals of *Synacanthotermes zanzibarensis* Sjöstedt (kindly identified for me by Prof. A. E. Emerson, of Chicago) under observation for a period of two months. The artificial nest contained several fragments of 'fungus garden' which were enlarged by the termites during the course of the observation. These were covered with mycelium and conidia. The termites never appeared to attack the mycelium. The conidia also generally remained immune from attack. But on two occasions conidia were eaten. After having been attacked by one worker, other workers which were passing near by were suddenly attracted and began to gnaw at the conidium. Sometimes four or five workers would be thus occupied, and the conidium was then completely destroyed within twenty minutes. Apart from these, no other conidia were attacked while the colony was under observation.

We may conclude that the conidia are immune for a long period; but that they are sometimes suddenly attacked and then eaten completely within a very short time, probably after having reached a certain degree of ripeness. This may explain why the actual process of devouring the conidia has never been observed previously, and also why partly destroyed conidia are never found in the 'fungus gardens'. They are attacked so rarely that they can scarcely play a large part in the nutrition of the termites, though they may possibly serve as a source of vitamins, as Grassé has supposed[5].

Production of heat by 'fungus gardens'. 'Fungus gardens' of *Macrotermes bellicosus* Smeathman, together with the brood and workers, were collected and placed in a 4-gallon can which was about three-quarters filled. After about four hours, the temperature in the container had risen to 35° C. while the surrounding temperature was 26° C. Early next morning the temperature was 40·5° C. and room temperature 21° C. This shows that there are probably fermentation processes going on in the 'fungus gardens' which lead to the production of

heat. The unnatural agglomeration of the 'gardens' in the can generated an exceedingly high temperature.

I then carried out some temperature measurements in a mound of the same species. The following measurements were made on October 11, 1949, in Ifakara (Tanganyika Territory) in the shade:

Site of temp. measurement	9 a.m.	4 p.m.
Air temperature	27° C.	31° C.
Surface of soil	27	32
Soil 4 cm. deep	25	29
,, 12 ,, ,,	25	26·5
,, 20 ,, ,,	25·5	26
Mound surface	27	31·5
,, 6 cm. deep (wall)	27	29
,, 10 ,, ,, ,,	28	28
,, 16 ,, ,, ,,	29	29
,, 20 ,, 'fungus gardens'	30	30
,, 28 ,, ,, ,,	30·5	30

The relative humidity in the wall was about 85 per cent, in the 'fungus garden' area 95 per cent. The temperature in the interior of the nest where the 'fungus gardens' lie scattered is always about 30° C. and remains very constant, at least in mounds standing in the shade of trees. In mounds exposed to the sun, the temperature in this region may rise by 2–3° C. in the afternoon.

These observations indicate that the 'fungus gardens' play a large part in conditioning the microclimate of the nest cavity of termite mounds. They not only maintain a constantly high humidity, which may be brought about by the metabolism of the fungi; but they also produce heat and play their part in maintaining a constant high temperature in the nest cavity. We suppose that this heat production is brought about by the activity of bacteria which may also be present in the "fungus gardens without fungi" found by Grassé and Noirot in the nests of *Sphærotermes sphærothorax* Sjöstedt[6].

I wish to thank Prof. R. Geigy, director of the Swiss Tropical Institute, for making possible my participation in the Swiss East Africa expedition.

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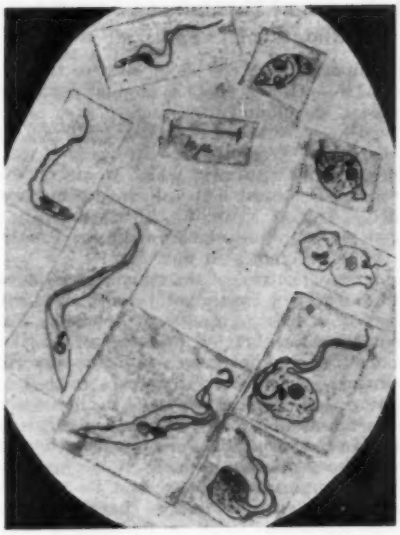
Occurrence of a Trypanosome in *Triatoma rubrofasciatus* in Calcutta

THE occurrence of a trypanosome as a parasite in a triatoma has hitherto escaped notice in India. In 1909 Donovan, however, reported the presence of crithidia in the intestines of *Triatoma rubrofasciatus* in Madras. *Triatoma rubrofasciatus*, the common Indian cone-nosed bug, is found almost exclusively in and near human habitations. It is usually active at night, frequently feeding on human blood.

Of forty-five specimens collected from different parts of Calcutta and examined, thirty-six adult insects and nymphs harboured in their guts a large number of trypanosomes in various stages of development.



For the purpose of observation each insect was treated in the following manner. The entire alimentary canal with the salivary glands was carefully dissected out. Smears were taken from: (*a*) teased salivary glands and the œsophagus; (*b*) mid and upper part of the lower intestines; (*c*) lower intestine containing the fæcal matter; and (*d*) the hæmocœle fluid.

All the smears were stained with combined Leishman and Giemsa stains and examined. It was found that (i) the hæmocœle fluid and the salivary glands and œsophagus revealed no parasites; (ii) the mid and lower sections of the intestine contained developmental forms of trypanosomes; (iii) the fæcal matter from the lower part of the intestines and the rectum contained only crithidia and trypanosomes.

The accompanying illustration is from a camera lucida drawing of the parasites.

As illustrated, the trypanosome is long and slender, often C-shaped, the posterior end tapering sharply to a point. The width of the undulating membrane is variable, being very narrow in the young forms. The nucleus is oval in shape, and it lies nearer the posterior end. The parabasal body is somewhat elongated and the flagellum is rather small.

MEASUREMENTS

	Average	Range
Length of the body	23 μ	20–27 μ
Length of the flagellum	11 μ	10–12 μ
Total length	34 μ	30–39 μ
Width of the body at nucleus	5 μ	4·9–5·3μ
Diameter of the nucleus	2·7 μ	2·4–3·3 μ
Distance of the nucleus from the posterior end	10·2 μ	9–11·6 μ
Distance between the nucleus and the parabasal body	4·2 μ	3·3–5·3 μ
Width of the undulating membrane	2·2 μ	2·1–2·4 μ

Further work on the subject is in progress.

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Influence of Shoot Apex on Subjacent Shoots of *Lupinus albus* L.

The importance of the shoot apex in the origin of tissues of the primary shoot is emphasized by numerous recent developmental studies (see review by Philipson[1]). The suggestion was made by Bower[2] that there is a "proleptic" sensitiveness of the tip to the incidence of similarity which would determine a stelar structure suitable to the size ultimately to be attained. Dixon[3] thought that the already differentiated procambium might precipitate procambium from the undifferentiated meristem.

The idea of control of the morphogenetic activity of the shoot apex by the subjacent, mature tissues was further utilized in studies of *Linum* by Esau[4], of *Sequoia* by Sterling[5], of *Ginkgo* by Gunckel and Wetmore[6], where the procambium was described as differentiating acropetally into the shoot apex into a position that would later have been the site of a foliar primordium. Ball[7] described a different relationship in *Lupinus albus*: a suspended strand of procambium that was produced in conjunction with the foliar primordium. Snow and Snow[8–10] demonstrated that it was possible to change the positions of future foliar primordia on the apex of this plant and of *Epilobium hirsutum* by longitudinal splits. The leaves produced after these operations appeared (from the illustrations given) to have normal vascular systems; it can be suggested that the shoot apices produced procambium in the positions appropriate to the new locations of the foliar primordia. It would seem, therefore, that in these plants the leaf determines the position of the procambium, and not vice versa. Snow and Snow[11] later demonstrated that undercutting the presumptive area of the second future leaf on the shoot apex of *L. albus* caused an interruption in the central strand of that leaf, but did not prevent the approximately normal development of the leaf. They concluded that leaf traces and the tissues from which leaf traces will be formed play no appreciable part in determining the positions of the leaves. The development and maturation of the subjacent shoots after the operations were not described by Snow and Snow.

This matter has particularly interested me, and suitable material for such studies was obtained after removing the central initials of the shoot apex of *L. albus* (Fig. 1). The lateral remains of the shoot apex frequently regenerated two normal apices—one on each side of the operation (Fig. 2). These new shoot apices then grew and left behind tissues that differentiated into two approximately normal shoots. The vascular systems of these new shoots appeared, in serial transections, to have been deposited on top of the previously existing procambial system. By following the illustrations, Figs. 3–24 (serial transverse sections of a shoot system sixty days after the operation on the shoot apex), it can be seen that a single ring of bundles gradually changed into two rings of bundles, each of which constituted the vascular system of a separate shoot. All these major

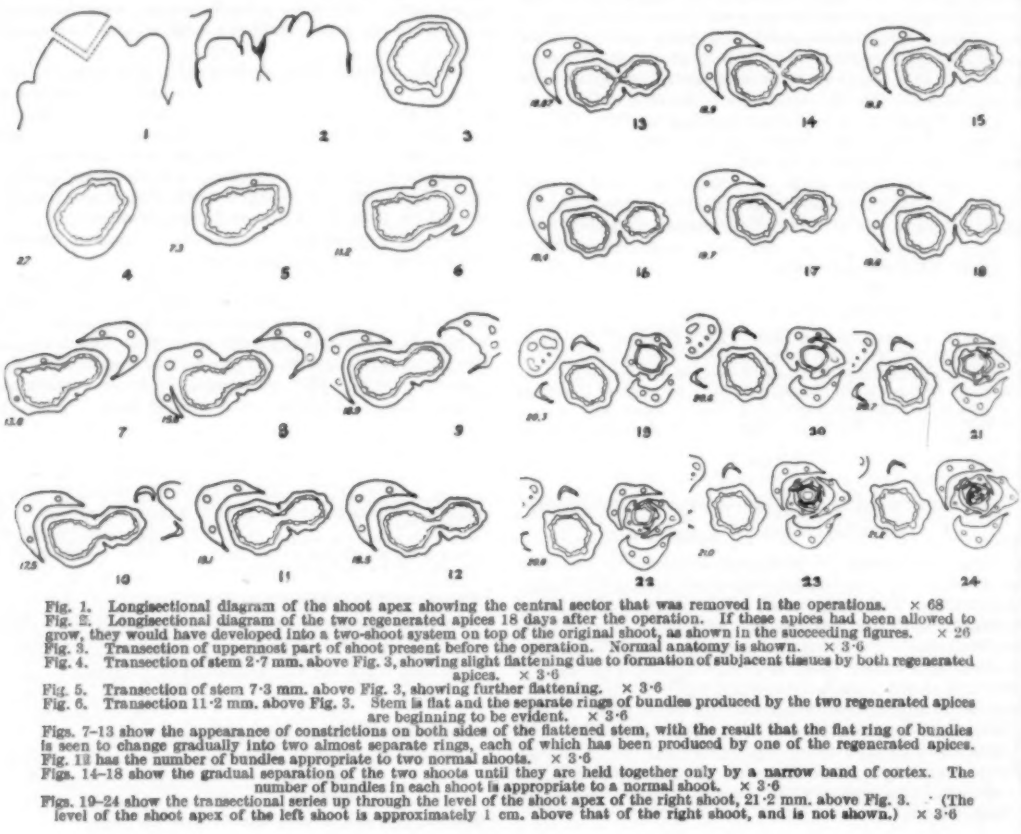

Fig. 1. Longisectional diagram of the shoot apex showing the central sector that was removed in the operations. × 68
Fig. 2. Longisectional diagram of the two regenerated apices 18 days after the operation. If these apices had been allowed to grow, they would have developed into a two-shoot system on top of the original shoot, as shown in the succeeding figures. × 26
Fig. 3. Transection of uppermost part of shoot present before the operation. Normal anatomy is shown. × 3·6
Fig. 4. Transection of stem 2·7 mm. above Fig. 3, showing slight flattening due to formation of subjacent tissues by both regenerated apices. × 3·6
Fig. 5. Transection of stem 7·3 mm. above Fig. 3, showing further flattening. × 3·6
Fig. 6. Transection 11·2 mm. above Fig. 3. Stem is flat and the separate rings of bundles produced by the two regenerated apices are beginning to be evident. × 3·6
Figs. 7–13 show the appearance of constrictions on both sides of the flattened stem, with the result that the flat ring of bundles is seen to change gradually into two almost separate rings, each of which has been produced by one of the regenerated apices. Fig. 13 has the number of bundles appropriate to two normal shoots. × 3·6
Figs. 14–18 show the gradual separation of the two shoots until they are held together only by a narrow band of cortex. The number of bundles in each shoot is appropriate to a normal shoot. × 3·6
Figs. 19–24 show the transectional series up through the level of the shoot apex of the right shoot, 21·2 mm. above Fig. 3. (The level of the shoot apex of the left shoot is approximately 1 cm. above that of the right shoot, and is not shown.) × 3·6

changes in the ontogeny of this plant were brought about by an operation upon the shoot apex.

The results of this experiment can be considered evidence that the shoot apex produces, and has a determining effect upon, the differentiation of the subjacent tissues of the primary shoot in this plant.

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Cytology of *Polypodium* in America

In two recent publications[1,2] on the cytogenetics of "*Polypodium vulgare*" the situation in Europe has been made fairly clear. There are three distinct species (perhaps ecospecies), one of which, the hexaploid, is probably of local origin and compounded of the other two, which are diploid and tetraploid respectively. The tetraploid, which covers northern Europe, is not closely related to the diploid, which has a more restricted and southerly range, and its origin must probably be looked for farther east, perhaps in Asia, in some birthplace or refuge area from which it has spread over the heavily glaciated countries of northern and central Europe.

Since *P. vulgare* in the wide sense is circumpolar in distribution with only a few significant gaps, information about non-European populations is essential to an understanding of it. In 1948, when the manuscript for the most recent statement[2] was actually compiled, only enough was known about these to indicate that the ancestral stocks must have spread over much, if not all, of their circumpolar range in the diploid condition, for Canadian material from both sides of the American continent had been found to be still in this state. A good deal of further information has since come to hand in the two years during which that statement was passing through the press, and the purpose of this note is to bring the published information more nearly up to date in the hope, among other things, of stimulating the interest of collectors to send additional samples of living material.

In the North American continent as a whole, "*P. vulgare*" occurs on both sides, though it is absent from the centre. On the eastern seaboard the sole representative is *P. virginianum*, a well-defined taxonomic species superficially resembling the European tetraploid, though diploid in constitution and undoubtedly specifically distinct. On the north-west of the continent, forms superficially resembling the diploid of Europe have sometimes been referred to[3,4] as *P. vulgare* var. *occidentale*, while in California there are numerous types, perhaps including these, which are variously split up into taxonomic species[4] under the names of *P. glycyrhiza*, *P. hesperium*, *P. californicum* and *P. Scouleri*.

Largely by the kindness of my colleague, Dr. H. G. Baker, and other correspondents, some material of all of these has been examined cytologically, together with one additional specimen from Hawaii. The results are as follows:

1.	*P. pellucidum* Klf.	Hawaii	Diploid
2.	*P. virginianum*	Nova Scotia	Diploid[5]
	"	Ontario	Diploid
3.	*P. vulgare* var. *occidentale* (= *P. glycyrhiza*)	Vancouver Island	Diploid[4]
	" "	Canadian Rockies	Diploid[4]
4.	*P. glycyrhiza* "	Mill Valley, California	Diploid
5.	*P. hesperium*	Columbia River, Oregon	Diploid
6.	*P. californicum*	near Portola, California	Tetraploid
		Searsville Lake, California	Tetraploid
7.	"*P. Scouleri*" three plants from Point Reyes, California, with different degrees of fleshy leaves. All showed hybrid meiosis. Two plants triploid and one diploid.		

One of the more striking facts which emerges from this list is the apparently tetraploid nature of *P. californicum* among a prevailing population of diploids. The hybrid swarm inhabiting Point Reyes is also of interest, although it precludes a successful diagnosis of the cytological status of *P. Scouleri* until purer material is to hand. Among the two triploids listed under 7, the leaves of one had the coriaceous character of *P. Scouleri* in an extreme degree though the leaves of the other were softer. Both showed n pairs and n univalents at meiosis. This contrasts strikingly with triploids found in Europe, in which practically all the chromosomes had remained unpaired[3]. This suggests that there are at least some tetraploids in California which are closer genetically to local diploids than is the case in Europe.

This problem is being further investigated by genetical means in Leeds.

While the most outstanding need from America is the provision of a purer sample of *P. Scouleri*, further samples of any species, especially from parts of the continent such as Baja California, which have not yet been represented, would be very welcome. At the same time, the importance of acquiring some knowledge of the state of affairs in Asia for interpretation of both the other continents is becoming increasingly obvious. In addition to Europe and Asia, "*P. vulgare*" is known to occur not only deeply into the heart of Russia but also, after a gap in central China, on the Pacific seaboard in eastern China, Korea and Japan. While it is obvious that under present conditions free collecting in any of these areas is out of the question, even one specimen from one of these localities would illumine to a unique degree the history of floras in the whole of the northern hemisphere.

I would be extremely glad to receive any additional samples of known wild origin from overseas, relevant to this problem. An ideal wrapping material for the rhizome of a live plant is the waxed paper lining of a 'corn flakes' packet, in which it can be slipped into an ordinary envelope and dispatched by letter post. Where available, air mail is to be preferred, but these plants are usually very hardy and can survive up to three weeks postal period if suitably wrapped. From very remote areas a fertile frond in a folded paper would suffice, though there is always a risk with spores that germination may fail. In all cases, exact details of the place of origin should be included, and all postal expenses will be gladly refunded to the sender if a name and address is enclosed.

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Stylonichia mytilus and the Lunar Periods

During a recent investigation at the University Botany School, Cambridge, of the association of ciliate protozoa and bacteria in a chalk stream, *Styl nichia mytilus* in common with other ciliate protozoa exhibited a series of 'pulses', or maximum waves when it spread down the stream, and minimum phases when it could be found only in the upper reaches. Forms in binary fission or conjugation were sometimes noted at the end of the maximum phase, whereas the minimum phase was generally marked by the appearance of small forms. The pulse of *Stylonichia* could not be related to any constant climatic or physical factor (rainfall, *p*H, temperature, etc.) or to total bacterial numbers at 22° C. or any particular group of bacteria. However, the maximum phase often occurred about a week to ten days after one of the lunar periods. From May to December 1947, the maximum phases occurred on twelve out of thirteen occasions a week to ten days after a new moon or a full moon: the greatest maximum peak was attained nine days after a new moon in July and four days after a full moon in December. By contrast with the dry weather and clear nights of 1947, the year 1948 was wet and dull. *Stylonichia* was only recorded between May and September, yet on five occasions it reached its maximum phase on an average eight days after a new or a full moon.

In the inquiry, samples for protozoological examination were always withdrawn from the stream opposite twelve fixed points, and an arbitrary estimation made of the numbers in not less than six drops of uniform size. A statistical analysis was made of the apparent association between *Stylonichia* and the lunar periods, and of its association with the full moon, as this was regarded as of particular interest, by the Statistical Laboratory of this University. The arbitrary numbers of *Stylonichia* were considered in relation to the lunar periodicity in days, and the report of the analysis was as follows. "The observations were classified according to the number of days after the full moon when they were made. Assuming the counts to be distributed in a Poisson distribution a χ^2 test was applied to see if the Poisson means were the same at all phases of the moon. In order to make the test valid, it was necessary to group the observations into sets of four days; the mean counts for each group were as follows:

Days after full moon	0–3	4–7	8–11	12–15	16–19	20–23	24–27	28–30
Mean count	0·5	2·0	1·0	1·0	0·7	1·0	1·8	0·5
No. of observations	4	6	3	5	3	5	5	2

"The value of χ^2 was 8·42 on 6 degrees of freedom, not significant. However, when the data were grouped by the number of days to the *nearest*, not the *last*, full moon, $\chi^2 = 8{\cdot}15$ was obtained on 2 degrees of freedom, significant at 5 per cent. This suggests that *Stylonichia mytilus* has a maximum about 4–7 days before and after a full moon, with slight evidence for a drop at the full moon itself. These statements will require more data before they can be made conclusive."

While fully agreeing with the last statement, the statistical analysis was not made until 1949, a year after the inquiry was completed, and it is perhaps remarkable that so suggestive a decision was reached on field-observations made with quite a different object in view. Alone, the observation might not be of so much interest were it not that *Stylonichia mytilus* is a diatom-eating ciliate and there is an abundant phytoplankton of diatoms in the stream concerned, which is swift, cold and shallow. Kofoid[1], in a statistical analysis of the phytoplankton of the Illinois River, records an association between the pulse of Bacillariæ (that is, diatoms) and the lunar periods. He states that the average lag of the phytoplankton pulse after the full moon was 13·7 and 14·8 days respectively and that the correlation of full moon and maximum phase of diatoms was most intimate in the stable conditions of summer when the average of the average monthly lags for all the May–August pulses was 11·9 days. In the absence of other information, it was assumed that in the particular stream examined the *Stylonichia* were following a lunar periodicity of diatoms (on which they fed) similar to that described by Kofoid in the Illinois. Maximum phases of the ciliate might follow therefore maximum phases of the diatoms, succeeded by periods of reproductive activity.

I wish to express my thanks to Mr. D. V. Lindley, who made the above statistical analysis.

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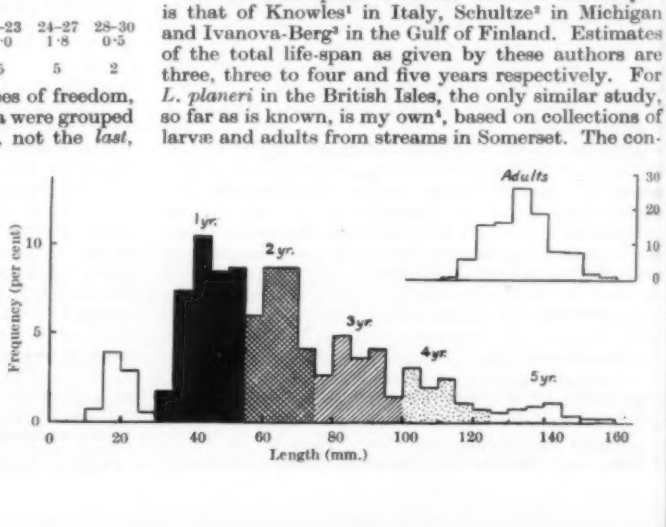
Duration of the Larval Period in the Brook Lamprey (*Lampetra planeri*)

Although the question of growth and the duration of the larval period in the brook lampreys has received considerable attention, the conclusions reached have been indecisive. In these animals, which spend the whole of their life in fresh-water, the problem is simplified in so far as the growth period ends at metamorphosis with the closure of the fore-gut and the cessation of feeding. Sexual maturity is reached in the first spring following metamorphosis, when the adult spawns and dies.

The most complete of recent work on this subject is that of Knowles[1] in Italy, Schultze[2] in Michigan and Ivanova-Berg[3] in the Gulf of Finland. Estimates of the total life-span as given by these authors are three, three to four and five years respectively. For *L. planeri* in the British Isles, the only similar study, so far as is known, is my own[4], based on collections of larvæ and adults from streams in Somerset. The con-



clusion then reached from a study of the frequency curves was that metamorphosis probably occurred when the ammocœte was three and a half to four and a half years old, giving a total life-span of four to five years. It was remarked, however, that both the rate of growth and the size of the adult vary considerably from one stream to another and even in different localities on the course of the same stream, so that conclusive results could only be expected if larvæ and adults are collected from a restricted area of a single stream.

Since my previous work, collections have been made in a restricted stretch of the River Yeo in Somerset, and from the additional data so obtained it would appear that the larval period for the population of this stream was under-estimated. The new material consists of the recorded lengths of 606 ammocœtes collected in June, July and August 1947–50 and 209 adults caught in April 1947 and 1950.

Length-frequency curves plotted for separate monthly collections indicate five yearly classes. The curve for the total material is reproduced in the accompanying histogram, with length-groups of 5 mm. and frequencies expressed as percentages. The first group, 10–30 mm., with a peak at 15–20 mm., consists of the youngest larvæ hatched during the spring of the current year. Further well-defined groups occur at 30–55, 55–75, 75–100 and 100–125 mm. with mean lengths estimated as about 40–45, 65, 85–90 and 105–110 mm., respectively. These groups represent ammocœtes in their second, third, fourth and fifth summers of growth. Over the remainder of the curve the number of specimens represented is small; but there is some indication of a further group at 125–160 mm. with a mean about 140–145 mm. That portion of the frequency curve from 100 mm. to 160 mm. would in any event be unlikely to consist of a single age-group, when consideration is given to the smaller dispersion of the adult frequency-curve, which extends from 110 mm. to 160 mm. with a mean of 133 mm. Moreover, allowance must be made for a reduction in length at sexual maturity[4,5], so that the fully grown ammocœtes would have an average length rather greater than that of the spawning adult. This condition is satisfied by the assumption that the part of the frequency-curve between 125 mm. to 160 mm. represents the mature larvæ.

It seems, therefore, safe to conclude that the larval period in this stream lasts more than five years, while the total life-span is exactly six years. Annual increments of growth in length will, on this interpretation, be very uniform, from 20 mm. to 30 mm., the greatest rate of growth occurring during the first and last years of larval life. This new information will make necessary a revision of conclusions previously arrived at regarding the larval period in other streams. It is hoped to publish elsewhere a more detailed re-examination of this question.

I should like to acknowledge my indebtedness to Mr. J. R. O'Connor for help with the collection of material.

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Blood Coagulation: its Prolongation in Vessels with Negatively Charged Surfaces

The clotting time of blood has for many years been known to depend upon the nature of the surface of the vessel in which it is contained. Freund[1] discovered that the coating of vessels with paraffin wax or with 'Vaseline' markedly delayed the clotting time of blood. Since that time there have been several reports of surface linings more effective in preserving blood, or more convenient to handle than paraffin wax. For example, collodion surfaces were advocated by Hirschboeck[2] and silicone by Jaques[3] *et al.* All attempts to produce new surface linings for the preservation of blood appear to have been based on the idea that the ideal surface would be water-repellent. A surface lining which is not water-repellent and which is suitable for the preservation of blood in a fluid condition for long periods is that of the vascular system. An alternative approach to the problem appeared, therefore, to be found in the preparation of synthetic surfaces resembling in structure the surface of blood vessels.

It is generally believed that the lining of the vascular system is composed of acidic polysaccharide material, for example, mucoitin. It is relatively simple to prepare artificial surfaces having similar physical and chemical properties to those of the natural polysaccharide sulphates. Polystyrene sodium sulphonate has been found to provide the most convenient artificial surface of this type. Its preparation and experiments illustrating its anticoagulant properties are described here.

The surfaces of small polystyrene test tubes were sulphonated by immersion for one minute at 100° C. in sulphuric acid containing 1 per cent silver sulphate[4]. Excess acid and silver salts were removed by washing in ammonia, and soluble polystyrene sulphonate by prolonged washing with dilute sodium bicarbonate. Human blood was collected by venipuncture, using a cold dry syringe, and transferred immediately to the sulphonated polystyrene tubes. The blood was also transferred to untreated polystyrene tubes and glass tubes of similar dimensions to the sulphonated tubes. The tubes were maintained at 20° C. and observed continuously until clotting occurred. The results of these tests are shown in the accompanying table; it can be seen that coagulation is slower in the hydrophilic sulphonated polystyrene tubes than in the water-repellent untreated polystyrene tubes.

Coagulation Time of Human Blood in Glass, Polystyrene and Sulphonated Polystyrene Tubes

Surface	Number of tubes tested	Coagulation time (min.)	Standard deviation of mean coagulation time
Glass	12	9·1	1·7
Polystyrene	16	29·3	10·1
Sulphonated polystyrene	28	41·5	15·3

In some of the experiments just described, a portion of the blood was removed from the sulphonated polystyrene tubes after 15 min. and transferred to glass tubes; clotting always occurred within three minutes of the transfer. The purpose of this test was to demonstrate that the preservation of the blood in the sulphonated tubes was not due to the dissolution from the surface of an anticoagulant, or to the adsorption of some component of the blood necessary for coagulation.

The observation that blood will remain fluid but unaltered when in contact with a highly negatively

charged surface suggests a possible explanation of continued fluidity of blood in the normal vascular system; the lining of the latter is similar physically to that of the sulphonated polystyrene tubes.

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Amino-acid Composition of Thymus Histone

In the course of our work on the chemistry of the constituents of the cell nucleus, nucleoprotein has been extracted from cell nuclei of normal and tumour tissue and fractionated into three main components: nucleic acid, the basic 'histone' protein and an acid-insoluble protein residue[1]. Quantitative amino-acid analyses are being carried out on these fractions. It was thought that the results obtained for calf thymus histone would be of value, since the results hitherto available account for only 50 per cent of the total composition[2].

The original nucleoprotein was extracted from the tissue using 1 *M* sodium chloride as described by Mirsky and Pollister[1]. The histone was extracted from the whole nucleoprotein with 0·05–0·1 *M* hydrochloric acid, and after dialysing the extract the histone was precipitated with ammonia. It was redissolved, dialysed and reprecipitated several times. Finally, after thorough dialysis against distilled water, it was freeze-dried. For analysis the protein was hydrolysed under reflux with 6 *N* hydrochloric acid for 16 hr.

Analysis of Thymus Histone
(Amino-acid nitrogen as percentage of total nitrogen)

Alanine	6·0	Leucine	3·05
Ammonia	4·8	Lysine	10·8
Arginine	30·7	Phenylalanine	1·9
Aspartic acid	3·3	Proline	2·7
Glutamic acid	2·25	Serine	3·45
Glycine	5·2	Threonine	3·1
Histidine	4·0	Tyrosine	1·4
*iso*Leucine	12·0	Valine	4·9
		Nitrogen recovery	99·5 per cent.

The accompanying table shows the results obtained by quantitative analysis, using chromatography on starch columns as described by Moore and Stein[3], of the histone from calf thymus.

The results have been corrected for decomposition of threonine and serine according to the data of Rees[4], and indicate that a 'recovery' of nearly 100 per cent has been obtained. The presence of the above components (fifteen amino-acids and ammonia) was also established qualitatively by paper chromatography, which also served to confirm the identity of the respective constituents in the separate fractions in the quantitative analysis. Davidson and Lawrie[5] reported the presence of thirteen amino-acids in thymus histone, one of which was not identified.

The presence of threonine in histone is reported for the first time in the results given above, and Kossel's observation[6] that histidine is a constituent is confirmed. An independent estimation of the tryptophane by a colorimetric method gave a very low content of 0·04 per cent. No cystine or cysteine could be detected polarographically in the protein.

This and other related work will be presented in greater detail in the future. The work is part of the research programme of the Birmingham Branch of the British Empire Cancer Campaign.

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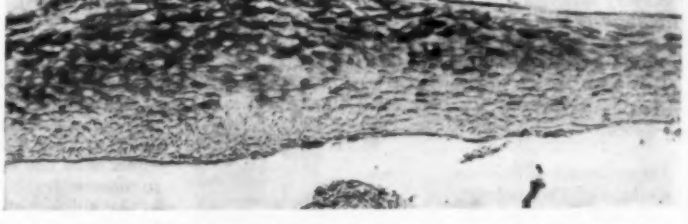
Glycogen of Vertebrate Epidermis

Claude Bernard, in 1859, described the abundant glycogen in the embryonic epidermis of several mammals (pig, cow and sheep)[1] and, in his last course of lectures[2], integrated these observations with the rest of his extensive studies on the histochemistry of glycogen. Later during the nineteenth century, the glycogen of embryonic epidermis was studied in some detail[3], but there appears to have been little recent work on this phenomenon, the significance of which remains unexplained.

In experiments designed to investigate the very different mucopolysaccharides of the dermis[4], in healing wounds of adult guinea pigs, we noted incidentally the abundance of glycogen in the regenerating epidermis. Details of these experiments (carried out during 1948) will be published elsewhere, but there is little doubt that, in animal tissues, glycogen is detected specifically by the histochemical method which was used (the alcoholic periodate-fuchsin stain[5], in conjunction with carefully controlled amylase digestion).

In undamaged epidermis, glycogen is absent, or present only in traces, after chemical fixation (ice-cold, non-aqueous fixative and thin slices of tissue). Undamaged epidermis prepared by freeze-drying contains slightly more glycogen, but still very little[6].



The regenerating epidermis of a mid-dorsal skin wound in a guinea pig, ten days after operation. The epidermis has separated both from the overlying scab and the underlying dermis. Glycogen (represented here by diffuse darkening of the cytoplasm) is absent from the 2–3 basal cell-layers, but very abundant in the outer half of the epidermis, particularly in the centre of the wound (left side of photomicrograph). Round the periphery (right), the glycogen concentration is already diminishing as the new stratum corneum is completed

On the other hand, glycogen is abundant in the regenerating epidermis (see photograph) as soon as the latter appears and begins to spread over the wound between the thick scab and the underlying dermal connective tissue. Glycogen is never present in stainable quantities in the two or three basal cell-layers of the epidermis, adjacent to the dermis, but is abundant throughout the rest of the new epidermis. About seven days after the wounding operation, the new epithelium completely covers the circular wound, and a new cornified layer of dead, flattened cells begins to form superficially, progressing from the periphery toward the centre and reducing epidermal thickness over the wound from 10–12 cell-layers down to the 4–5 cell-layers found in the adjacent undamaged skin. As the outermost cells keratinize, they lose their glycogen. Finally, when the scab sloughs off (about fourteen days after wounding), glycogen content throughout the new epidermis has diminished to the level present in undamaged skin, that is, it can no longer be stained after chemical fixation, or appears only spasmodically in isolated cells of the stratum spinosum.

Glycogen appears in stainable quantities in a wide variety of tissue environments. Its metabolic significance is fairly well understood in some of these sites—for example, muscle, liver and regions of calcium phosphate deposition[7]—but quite unknown in others. The main synthetic process occurring in the outer layers of regenerating epidermis is synthesis of keratin. Yet many sites of active protein synthesis contain very little glycogen (pancreas, fibroblasts, silk glands). It seems at present that the most probable explanation of this peculiarity of the epidermis lies in its poor supply of glucose and oxygen, since the layer of new epidermis 10–12 cells thick is devoid of blood vessels (and of dermal villi) and is covered by a thick scab. Of the various pathways of internal respiration which supply energy for chemical synthesis, those requiring oxygen are therefore likely to be blocked and the cells thrown back on to anaerobic glycolysis—a process yielding much less energy per molecule of glucose used than is liberated during the complete aerobic breakdown of glucose to carbon dioxide. For a given amount of protein synthesis, the epidermal cells will therefore require abnormally large quantities of glucose; but here again the absence of epidermal blood vessels must pose serious difficulties, in spite of the special intercellular spaces in the stratum spinosum. Hence it is not surprising to find that, as soon as the cells leave the basal layers of the epidermis and commence their outward migration to the surface, they store large reserves of glycogen, which are later used to supply energy for protein synthesis, and are finally exhausted as the cells become transformed into dead, keratinized plaques. It would be interesting to know whether glycogen is similarly abundant in the middle and outer layers in other cases where vertebrate epidermis effects rapid keratin synthesis—particularly during the moulting of reptile epidermis, where the stratification closely resembles that of mammalian epidermis[8]. It is significant that so long as the cells are situated in the basal epidermal layers, separated only by basement membrane from the vascularized dermis, they never contain demonstrable amounts of glycogen.

Most striking among the examples described by Claude Bernard is the hoof of the embryonic cow, which shows clearly how the abundant glycogen of the soft inner layers disappears from each cell as the latter becomes keratinized and added on to the outer, horny layer of the hoof. He suggested tentatively that glycogen might actually be incorporated as such into the keratinized tissue[1,2]; but it now seems more likely that the explanation is similar to that proposed above regarding the behaviour of glycogen in the regenerating epidermis of skin wounds, namely, the absence of blood vessels in the epidermis results in a poor supply of glucose and oxygen, and, just as the scab excludes atmospheric oxygen, so the developing hoof hinders what little oxygen might diffuse in from neighbouring placental tissue. Hence abundant intracellular supplies of glycogen are necessary to support the anaerobic glycolysis imposed on the epidermal cells, and this glycogen disappears as it is used to supply the energy for keratin synthesis, so that the outermost layers of skin and hoof no longer contain appreciable amounts of this substance.

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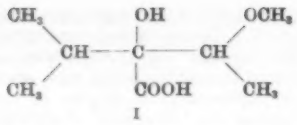
Structure of Lasiocarpic Acid

In view of recent publications[1,2] dealing with the structures of the esterifying acids of the pyrrolizidine group of alkaloids, it seems desirable to place on record the following data relating to lasiocarpic acid obtained from the alkaloid lasiocarpine. Lasiocarpine, together with heliotrine, was first isolated by Men'shikov[3] from *Heliotropium lasiocarpum* F. and M. Later, Trautner and Neufeld[4] obtained lasiocarpine from *H. europæum* L. growing in Australia and found it to be accompanied by *iso*heliotrine, a base differing from Men'shikov's heliotrine only in respect of its optical rotation. Trautner and Neufeld's work has been repeated and confirmed except for the yields of the two alkaloids. Lasiocarpine from *H. europæum* is clearly identical with the alkaloid from *H. lasiocarpum*, giving, on hydrolysis and hydrogenolysis, products the properties of which are in complete agreement with those described by Men'shikov and Schdanovitch[3]. Likewise, *iso*heliotrine gives, on hydrolysis and hydrogenolysis, products having the same properties, including optical rotation, as those reported from heliotrine, despite the differences in rotation of the parent bases.

Structure I for heliotric acid, $C_9H_{16}O_4$, the acid resulting from hydrolysis or hydrogenolysis of heliotrine, was established by Men'shikov[3] by oxidation to 2-methyl-4-methoxypentan-3-one, and the same result has been obtained with heliotric acid from *iso*heliotrine. Lasiocarpic acid, $C_9H_{16}O_5$, not stable to alkali, was obtained by Men'shikov and Schdanovitch by hydrogenolysis of lasiocarpine and was shown by them to contain one methoxyl and two hydroxyl groups. These two hydroxyl groups are now shown to be present as an α-glycol grouping, since on titration with sodium periodate 1·01 moles of periodate are consumed per mole of lasiocarpic acid. Moreover, fission of the glycol with periodate



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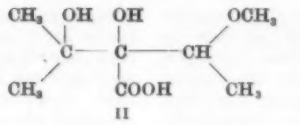

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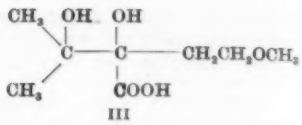
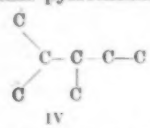


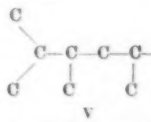
III

leads to the formation of acetone, isolated and identified as its 2,4-dinitrophenylhydrazone. Lasiocarpic acid is an α-hydroxy acid, for it gives a yellow colour with ferric chloride and liberates carbon monoxide on warming with concentrated sulphuric acid. Only two possible structures for lasiocarpic acid, (II) and (III), are consistent with these facts, and a decision between them can be made on the basis of Kuhn–Roth C-methyl determinations. As would be expected, heliotric acid, with one terminal methyl group and a *gem*-dimethyl group, gave 1·6 moles acetic acid. Lasiocarpic acid gave 1·6 moles acetic acid, showing that it also contains one terminal methyl group and a *gem*-dimethyl group and therefore possesses structure II.

It is noteworthy that, with the exception of angelic acid, a second acid fragment from lasiocarpine, the esterifying acids of pyrrolizidine alkaloids from four genera of the family Boraginaceæ—*Heliotropium*, *Lindelofia*[5], *Cynoglossum*[5] and *Trachelanthus*[5]—all have the same C_7 skeleton (IV), in contrast to the C_{10} di-isoprene necic acids (V) from *Senecio* spp.[1]. It is probable that the carbon skeleton of the esterifying acid (other than lactic acid) is the same in the case of trichodesmine from *Trichodesma incanum*[3], the only other member of the Boraginaceæ reported to contain pyrrolizidine alkaloids.



IV



V

Full details of this work will be published elsewhere.

L. J. Drummond

Division of Industrial Chemistry,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne. Aug. 24.

[1] Kropman, M., and Warren, F. L., *J. Chem. Soc.*, 700 (1950).
[2] Adams, R., *et al.*, *J. Amer. Chem. Soc.*, **72**, 155 and 158 (1950).
[3] Henry, T. A., "The Plant Alkaloids" (4th edit., London, 1949).
[4] Trautner, E. M., and Neufeld, E. O., *Aust. J. Sci.*, **11**, 211 (1949).
[5] Men'shikov, G. P., *et al.*, *J. Gen. Chem. U.S.S.R.*, **17**, 343 (1947); **18**, 1736 and 1836 (1948).

Preparation of D-Glucose Dibenzamide from Pentabenzoyl-D-α-Glucose

The usual reaction product of the treatment of the acylated nitriles of aldonic acids with ammonia are the aldose diacetamides[1]. A variation of this reaction was found when Hockett and Chandler[2], by treating hexa-acetyl-D-α-glucoheptonic acid nitrile with ammonia, obtained N-acetyl-D-glucofuranosylamine. The same product resulted from the action of ammonia on penta-acetyl-aldehydo-D-glucose. Later, Niemann and Hays[3] prepared N-acetyl-D-glucofuranosylamine by the action of methanolic ammonia on penta-acetyl-D-β-glucose, a reaction that produced the transformation of the original pyranose ring of the acetylated glucose into a furanose structure.

We have found that if pentabenzoyl-D-α-glucose is treated with methanolic ammonia, D-glucose dibenzamide is produced in 28 per cent yield. The product is identical with the D-glucose dibenzamide prepared by Brigl, Mühlschlegel and Schinle[4] by the action of the same reagent on pentabenzoyl-aldehydo-D-glucose. Melting point and rotatory power were identical for the compounds prepared by the two reactions, and a mixed melting point gave no depression. The same penta-acetyl derivative was obtained by acetylation of D-glucose dibenzamide prepared from pentabenzoyl-D-glucose and from pentabenzoyl-aldehydo-D-glucose (melting point, 193–194°; $[\alpha]_D^{22°} - 39·7°$ in chloroform. Calculated for $C_{30}H_{34}N_2O_{12}$: C, 58·60; H, 5·54; N, 4·56; found: C, 58·86; H, 5·12; N, 4·85 per cent).

The reaction is significant as a demonstration of the influence of the acyl groups in it. It is being studied in detail in relation with the theory proposed by Isbell and Frush[5] to explain the formation of aldose-diamide compounds, for which there is experimental proof in the work of Hockett, Deulofeu and Deferrari[6] employing ammonia labelled with nitrogen-15 for the degradation of acylated nitriles of aldonic acids.

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Facultad de Ciencias Médicas.
Cátedra de Química Orgánica,
Facultad de Ciencias Exactas,
Físicas y Natura'es,
Buenos Aires.
Aug. 1.

[1] Full bibliography in Deulofeu, "Advances in Carbohydrate Chemistry", **4**, 119 (New York Academic Press, 1949).
[2] Hockett and Chandler, *J. Amer. Chem. Soc.*, **66**, 957 (1944).
[3] Niemann and Hays, *J. Amer. Chem. Soc.*, **67**, 1302 (1945).
[4] Brigl, Mühlschlegel and Schinle, *Ber.*, **64**, 2921 (1931).
[5] Isbell and Frush, *J. Amer. Chem. Soc.*, **71**, 1579 (1949).
[6] Hockett, Deulofeu and Deferrari, *J. Amer. Chem. Soc.*, **72**, 1840 (1950).

Structure of Ribose Anhydride

During the removal of the triphenylmethyl (trityl) group from 1 : 2 : 3-triacetyl 5-trityl D-ribofuranose, Bredereck, Köthnig and Berger[1] observed the formation of a compound to which they assigned the structure 1 : 5-anhydro-D-ribofuranose. Doubts as to the validity of this structure were raised by two of us, and using the method described by the German workers, a compound was obtained which was shown to have the structure 1 : 5′ - 5 : 1′-di-D-ribofuranose anhydride[2]. However, owing to the lack of agreement in the specific rotation of the anhydride with that recorded by Bredereck *et al.*, it could not be concluded that the two compounds were identical, although apparently the same method of preparation was used in each case.

Prior to the publication of the above dimeric structure, preliminary investigations by one of us (R. W. J.) had also led to the conclusion that Bredereck's monomeric structure was untenable[3], though no evidence had then been obtained to indicate an alternative structure. Furthermore, the discovery (R. W. J.) of an arithmetical error in the calculation by Bredereck *et al.* of the specific rotation

Anhydroribose	Bredereck *et al.*	R. W. J.	G. R. B. and M. V. L.
m.p.	229–230° (sint. 225°)	231–232° (sint. 223°)	229° (sint. 224°)
Specific rotation in water	$[\alpha]_D^{20°}$ +7·8° + 7·9°*	$[\alpha']_D^{20°}$ +8·6° ± 0·5° (*c*, 1·33)	$[\alpha]_D^{18°}$ +9·4° ± 0·5° (*c*, 1·4)
Consumption of periodate		2·00, 1·92, 2·08 mol. (no formic acid produced)	2·03, 2·01 mol. (no formic acid produced)
Specific rotation of solution after oxidation		$[\alpha']_D^{20°}$ +46·5° ± 0·5°	$[\alpha]_D^{19°}$ +48° ± 0·7°†
Tetra-acetyl anhydroribose			
m.p.	169°	169–169·5°	168·5–169·5°
Specific rotation in chloroform		$[\alpha']_D^{20°}$ +51·0° ± 0·5° (*c*, 0·97)	$[\alpha]_D^{18·5°}$ + 50·6° (*c*, 1·19)

* Arithmetical error corrected.
† This was incorrectly published as − 48°. We are indebted to Dr. Jeanloz for pointing out the mistake and have verified the sign by a second determination (G. R. B., M. V. L.).

of the anhydride removed the doubt previously expressed[2] as to the identity of the two materials.

In the accompanying table, we record the close agreement reached by the various authors, including some fresh data, and we wish to emphasize that the compound originally prepared by Bredereck, Köthnig and Berger is now to be regarded as 1 : 5′-5 : 1′-di-D-ribofuranose anhydride.

R. W. Jeanloz

Worcester Foundation for Experimental Biology, Shrewsbury, Mass.

G. R. Barker
M. V. Lock

Department of Chemistry, University, Manchester 13. Sept. 14.

[1] *Ber.*, **73**, 956 (1940).
[2] Barker, G. R., and Lock, M. V., *J. Chem. Soc.*, 23 (1950).
[3] Private communication.

Quick Test for the Early Diagnosis of Influenza

During infection of mice with influenza virus, the hæmagglutinin inhibitor, normally present in their respiratory mucus, disappears[1]—presumably due to degradation by the enzyme of the multiplying virus[2]. Human nasal secretions contain a similar substance which, when acted upon *in vitro* by influenza virus enzyme, loses its inhibitory capacity. As the disappearance of inhibitor was shown to be one of the most sensitive diagnostic signs of influenza in mice[3], it seemed promising to apply the same method to the human disease. The recent epidemic of influenza *A* in Melbourne offered an opportunity of testing this proposition.

Nasal swabs were soaked in 1·0 ml. 0·9 per cent sodium chloride solution, and the inhibitory titre of the extracts was determined. Since even in normal persons the inhibitor content of nasal secretions varies widely, advantage was taken of the recent work on the adsorptive affinity of mucoids for different strains of influenza virus. As established by Stone[4], each inhibitor shows a characteristic pattern when tested against a series of indicator viruses[5]; contact with active virus results in differential reduction of titres for the various indicators, that is, in a distortion of the normal pattern.

The samples were therefore titrated against three virus strains, *WS*, *MEL*, *LEE*, in parallel. In tests on 137 specimens from twenty-nine normal individuals, the average ratio of titres against *WS* : *MEL* : *LEE* was 10 : 24 : 9. For convenience the findings are expressed in terms of the 'inhibitor index', $10 \times \frac{MEL + LEE}{WS}$. Thus the inhibitor index for normal human nasal secretions is 33 with a standard deviation of ± 8. Since the *WS*-inhibitor is the one most readily destroyed, the inhibitor index will rise whenever the mucus is acted upon by a viral enzyme.

The accompanying table summarizes the results obtained during the first month of the epidemic. The tests applied were: (*a*) determination of the inhibitor index; (*b*) amniotic isolation of the virus; (*c*) titration of antibodies directed against the virus particle; and (*d*) estimation of complement-fixing antibody.

Contingency Table of Diagnostic Tests for Influenza
Based on the investigation of 84 patients during the 1950 epidemic of influenza *A* in Melbourne

a	*b*		*c*		*d*	
Inhibitor index	Virus isolation		Anti-hæmagglutinin		Complement-fixing antibody	
	+	−	+	−	+	−
> 100 (+ +)	4	0	2	0	3	0
75–100 (+)	6	2	7	0	6	0
50–75 (±)	11	4	6	3	6	4
< 50 (−)	2	28	3	39	2	45

$\chi^2_{ab} = 27·9$; $\chi^2_{ac} = 31·4$; $\chi^2_{ad} = 40·0$.
(For purposes of the χ^2-test all inhibitor indices exceeding 50 are considered positive. Yates's correction for small numbers was applied.)

The χ^2-values calculated relative to the inhibitor index (cf. table) are of the same order as those obtained when the three tests are evaluated accordingly ($\chi^2_{bc} = 17·1$, $\chi^2_{bd} = 19·1$, $\chi^2_{cd} = 41·7$), thus proving a very high positive correlation. Hence, the proposed procedure may be listed among those giving objective evidence of influenza virus infection in man. The technique is simple, and an answer is available within an hour's time.

The inhibitor profile remains distorted during the first three to five days after the onset of symptoms; by the time antibody appears, all patients have their inhibitor indices within the normal range (< 50). No deviations from the normal were seen in a limited number of experiments on various other diseases of the respiratory tract (two lobar and three bronchopneumonias, one atypical pneumonia, two cases each of bronchiectasis, tracheo-laryngitis, and pharyngitis, and seven cases of common cold). Though it is quite realized that the number of controls has to be extended, the information available would suggest that enzymic destruction of the hæmagglutinin inhibitor of nasal mucus is restricted to infection with influenza viruses.

A full report on the work will appear elsewhere. I am greatly indebted to my colleagues in the Epidemiological Unit for collecting specimens and for making available the results of their investigations.

S. Fazekas de St. Groth

Walter and Eliza Hall Institute of Medical Research, Melbourne. Sept. 5.

[1] Fazekas de St. Groth, S., *Austral. J. Exp. Biol.*, **28**, 15 (1950).
[2] Gottschalk, A., and Lind, P. E., *Nature*, **162**, 232 (1949).
[3] Fazekas de St. Groth, S., *Lancet*, i, 1101 (1950).
[4] Stone, J. D., *Austral. J. Exp. Biol.*, **27**, 557 (1949).
[5] Stone, J. D., *Austral. J. Exp. Biol.*, **27**, 337 (1949).

FORTHCOMING EVENTS

(Meetings marked with an asterisk • are open to the public)

Monday, January 8

ASSOCIATION FOR THE STUDY OF ANIMAL BEHAVIOUR (at the Zoological Society of London, Regent's Park, London, N.W.8), at 11 a.m.—Symposium on "Grazing Behaviour" (to be opened by Sir George Stapledon, F.R.S., Prof. Martin Jones and Dr. John Hammond, F.R.S.).

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Dr. John C. Swallow: "The Plastics Industry" (Cantor Lectures). (Further Lectures on January 15 and 22.)

Tuesday, January 9

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. C. J. Stairmand: "The Sampling of Dust Laden Cases".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Sir Henry Dale, O.M., F.R.S.: "The Scientific Basis of Medicine, 1, The Significance of Acetylcholine as a Chemical Transmitter of the Effects of Nerve Impulses".• (Further Lectures on January 11, 16, 18, 23, 25, 30, February 1, 6, 8, 13, 15, 20, 22, 27, March 1, 6, 8, 13, 15 and 20.)

ILLUMINATING ENGINEERING SOCIETY (at the R.I.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. W. Robinson: "Brightness Engineering".

INSTITUTION OF WORKS MANAGERS, PRESTON GROUP (at the Preston and District Building Trades Employers Association, Starkie House, Starkie Street, Preston), at 7 p.m.—Mr. W. Place: "Methods—Time Measurement, a Recent Development in Time Study".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the GRAVESEND AND DISTRICT ENGINEERING SOCIETY, at the Royal Clarendon Hotel, Gravesend), at 7.30 p.m.—Mr. J. Smith: "Atomic Reactors, their Development and Economics."

Wednesday, January 10

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGICAL PANEL of the FOOD GROUP (joint meeting with the SOCIETY FOR APPLIED BACTERIOLOGY, at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 2.15 p.m.—Symposium on "The Cytology of Bacteria".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. C. Potter: "Insecticides and their Study" (Fernhurst Lecture).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Papers on "The I.P. Safety Codes" (Mr. E. J. Sturgess: General Considerations; Mr. H. de Wilde: Their Application to Production; Dr. F. Mayo: Their Application to Refining; Mr. R. L. Sarjeant: Their Application to Marketing).

MANCHESTER STATISTICAL SOCIETY (at the Reform Club, King Street, Manchester), at 5.30 p.m.—Prof. M. S. Bartlett: "The Theory of Statistics".

ROYAL MICROSCOPICAL SOCIETY, BIOLOGICAL SECTION (at Tavistock House South, Tavistock Square, London, W.C.1), at 6 p.m.—Dr. Joan Lorch: "Micro-Dissection Studies on Amœbæ".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—A Symposium on "Hearing Aids".

Wednesday, January 10—Monday, January 15

WORLD POWER CONFERENCE (at New Delhi, India).—Sectional Meeting; First Plenary Session of the International Commission on Irrigation and Canals; Fourth Congress on Large Dams.

Thursday, January 11

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 5 p.m.—Dr. I. G. H. Isbak (Cairo): "Colour Vision Characteristics of Egyptian Trichromats".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. F. S. Edwards, Mr. F. R. Perry and Mr. A. S. Husbands: "Development and Design of High Voltage Impulse Generators".

BRITISH TRUST FOR ORNITHOLOGY in co-operation with the BRITISH ORNITHOLOGISTS' UNION (at the Zoological Society of London, Zoological Gardens, London, N.W.8), at 6 p.m.—Mr. R. A. H. Coombes and others: "International Wildfowl Research".

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow), at 7 p.m.—Mr. E. D. Hart and Mr. A. G. Wray: "Frequency Modulation and F.M. Measuring Equipment".

LIVERPOOL METALLURGICAL SOCIETY (in the Lecture Theatre, Electricity Service Centre, Whitechapel, Liverpool), at 7 p.m.—Mr. H. Morrough: "The New Nodular Cast Irons".

Friday, January 12

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

CHEMICAL SOCIETY, ST. ANDREWS AND DUNDEE SECTION (joint meeting with the ST. ANDREWS UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Department, United College, St. Andrews), at 5 p.m.—Dr. R. A. Raphael: "The Synthesis of some Natural Products by means of Acetylenic Compounds".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. Denis Taylor and Mr. E. H. Cooke-Yarborough: "The Use of Electronic Measuring Instruments in Nuclear Physics and Nuclear Engineering".• (Further Lectures on January 19, 26, February 2, 9 and 16.)

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Mr. I. Lubbock: "Combustion Problems of Gas Turbines".

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (at the Albert Hall, Peter Street, Manchester), at 6.45 p.m.—Mr. S. Wiseman: "Intelligence Testing, its Methods and Statistical Basis".

Saturday, January 13

INSTITUTION OF CHEMICAL ENGINEERS, MIDLAND BRANCH (in the Latin Theatre, The University, Edmund Street, Birmingham), at 3 p.m.—Mr. F. H. Garner and Mr. S. R. M. Ellis: "Applicability of Vapour-Liquid Equilibria to Extractive Distillation".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ENGINEERING ASSISTANT IN THE X-RAY SECTION of the Ministry of Supply Engineering Division, for duty in Edinburgh or Glasgow—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.342/50A (January 12).

PHYSICISTS and LIGHT ELECTRICAL ENGINEERS (Principal Scientific Officer grade) (with a good honours degree and a wide background of research and development experience, particularly in the design and use of magnetic and electronic amplifiers) at the Royal Aircraft Establishment, Farnborough, Hants—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.345/50A (January 12).

LECTURER, with special responsibility in Physics—The Registrar, Birmingham Central Technical College, Suffolk Street, Birmingham 1 (January 13).

LECTURER IN MATHEMATICS for B.Sc. (general) and/or H.N.C. in engineering (mechanical and electrical), at the Luton and Bedfordshire College of Further Education—The Borough Education Officer, Education Office, Town Hall, Luton, Beds (January 13).

MECHANICAL ENGINEER for the Ministry of Works Engineering Division in London, for service in the Heavy Research Plant Section on the design and execution of large engineering installations for Government Research and Scientific Establishments—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.652/50A (January 13).

SCIENTIST, Grade III (with a good honours degree, or equivalent, in mathematics, physics or engineering), to carry out operational research—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/279 (January 13).

CHEMISTS (with honours degree or equivalent) for research and routine investigations on tropical soils and crops in Nyasaland (Ref. 27106/17), Kenya (Ref. 27106/34), Gold Coast (Ref. 27059/268), Malaya (Ref. 27106/30), and for soil analysis in Nigeria (Ref. 27059/199)—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting the appropriate Ref. No. (January 14).

ECONOMIST (Senior Professional Officer, grade III) in the Department of Trade and Industrial Development, Southern Rhodesia—The Secretary to the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (January 15).

SCIENTIFIC OFFICERS (9) IN THE DEPARTMENT OF AGRICULTURE, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (January 15).

SENIOR LECTURER IN VETERINARY ANATOMY, a LECTURER IN VETERINARY ANATOMY, a LECTURER IN BIOLOGY, and an ASSISTANT LECTURER IN BIOLOGY—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (January 15).

DAIRY CATTLE HUSBANDRY OFFICER—The Director, Animal Breeding and Genetics Research Organization, Glenbourne, South Oswald Road, Edinburgh 9 (January 20).

SENIOR LECTURER IN MATHEMATICS—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (January 20).

LECTURER IN THE DEPARTMENT OF ZOOLOGY, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Rondebosch, January 31).

SENIOR ASSISTANT IN THE DEPARTMENT OF ANATOMY of the Medical School, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Rondebosch, January 31).

ADVISORY OFFICER FOR AGRICULTURAL EDUCATION—The Director of Education, Castle Street, Worcester.

AGRICULTURAL ADVISORY OFFICER in North-East India—The Secretary, Indian Tea Association, 39 Lombard Street, London, E.C.3.

CHEMISTS and CHEMICAL ENGINEERS (Scientific Officer grade) (with a good honours degree or equivalent in chemistry or chemical engineering) in Ministry of Supply experimental establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.726/50A.

LECTURER IN CHEMISTRY in the Department of Applied Chemistry—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

MECHANICAL ENGINEERS in the Colonial Engineering Service as Inspectors of Machinery in the Mines Department of the Federation of Malaya—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27099/23.

RESEARCH OFFICER with degree in physics or equivalent (considerable skill in the finer techniques of physical measurement desirable), a RESEARCH OFFICER, with degree in physics or equivalent, for work on full- or semi-scale plant, eventually to supervise technical investigations on dust and pulverizing, and RESEARCH OFFICERS preferably with degree in physics or equivalent, for work on small-scale combustion problems—The Assistant Secretary, British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

THE FOLLOWING ADDITIONAL STAFF will be required early in 1951 for a chemical works in Lancashire, manufacturing organic chemicals for the rubber, pharmaceutical, disinfectant and insecticides trade. 1. Organic Chemist for preparative work in a wide field in connection with a long-term investigation. 2. Chemist for development of laboratory processes on a semi-technical scale, prior to manufacture. 3. Analytical Chemist to take charge of small works testing laboratory. For all the above posts candidates should preferably be qualified and should not be over 30 years of age, with the possible exception of the second vacancy. We would also welcome applications from university students expecting to qualify in 1951. Salary will be commensurate with qualifications and experience. —Candidates should write, giving full details, to Box 190, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

ENGINEERS AND PHYSICISTS ARE required for experimental work in the following fields: (a) communications, (b) illumination, (c) spheroid appliances, (d) microwave test bench equipment, (e) radio valves, (f) waveguides. A degree or higher national certificate or equivalent is essential, and preference will be given to candidates between 22 and 30. Good starting salaries will be paid with excellent prospects.—Applications, in writing, should be addressed to the Personnel Officer (Ref. GBLC/442), Research Laboratories of the General Electric Co., Ltd., East Lane, North Wembley, Middlesex, stating age, qualifications and experience.

YOUNG GRADUATE CHEMISTS ARE required in the antibiotic production factory of Glaxo Laboratories, Ltd., at Ulverston, Lancs. In departments concerned with fermentation, extraction and crystalline processes. A good honours degree in chemistry is required, and applicants should preferably have an interest and training in physical chemistry or industrial chemistry. The posts are pensionable and successful applicants will participate in the Company's incentive scheme.—Apply, in writing, to Personnel Department, Glaxo Laboratories, Ltd., Greenford, Middlesex.

APPOINTMENTS WANTED

WOMAN, L.S.E. GRADUATE, SEEKS POST of responsibility; considerable experience in the application of statistical methods; languages.—Box 191, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

B.Sc., F., 24, CHEM. and MATHS., EXPERIenced scientific abstracting and information, typing, studying statistics (F.R.S.S.), requires position of responsibility.—Box 401, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

FOR SALE AND WANTED

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MISCELLANEOUS

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D. W. LOGAN,
Principal.

GRANTS & SCHOLARSHIPS

NUFFIELD FOUNDATION
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The Nuffield Foundation, as part of its programme for the advancement of sociological studies, is prepared to offer for the academic year 1951-2 a limited number of scholarships and bursaries to enable graduates in other academic subjects, especially science and mathematics, to transfer to the social sciences. The Foundation's particular object is to enable such persons to receive a training in, for example, political science, social psychology, anthropology, social statistics and sociology generally (but not economics) so as to enable them to undertake research and teaching in the United Kingdom in those subjects. The scholarships, which are the senior awards, are intended for persons who have already undertaken some postgraduate work in their own subject. The bursaries are intended to enable those who have recently graduated to take a course of training in sociological subjects. Graduates of universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35 are eligible to apply.

Applications for awards in 1951 must be received before May 1, 1951, by the Secretary, The Nuffield Foundation, 12 and 13 Mecklenburgh Square, London, W.C.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN,
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Applications should be made by letter, and should be accompanied by a statement of the research proposed, evidence that the candidate, if successful, will be granted research facilities, and the names of three referees as to the candidate's qualifications. Testimonials should not be sent. One of the referees should be the Head of the Department in which the proposed research is to be carried out. Applications are required to reach—The Secretary, Courtaulds' Scientific and Educational Trust Fund, 16 St. Martin's-le-Grand, LONDON, E.C.1, not later than February 15, 1951.

NUFFIELD FOUNDATION
BIOLOGICAL SCHOLARSHIPS AND BURSARIES

The Nuffield Foundation, as part of its programme for the advancement of biological studies, is prepared to offer for the academic year 1951-2 a limited number of scholarships and bursaries to enable graduates in the physical sciences or in mathematics to receive such training in biology as will enable them to undertake research and teaching in the United Kingdom in the biological sciences. The scholarships, which are the senior awards, are intended for persons who have already undertaken some postgraduate research. The bursaries are intended to enable those who have recently graduated in physics or chemistry or mathematics to complete a further course of training in biological subjects. Graduates of universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1951 must be received before May 1, 1951, by the Secretary, The Nuffield Foundation, 12 and 13 Mecklenburgh Square, London, W.C.1, from whom full particulars and application forms can be obtained.

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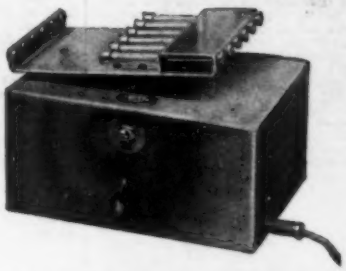

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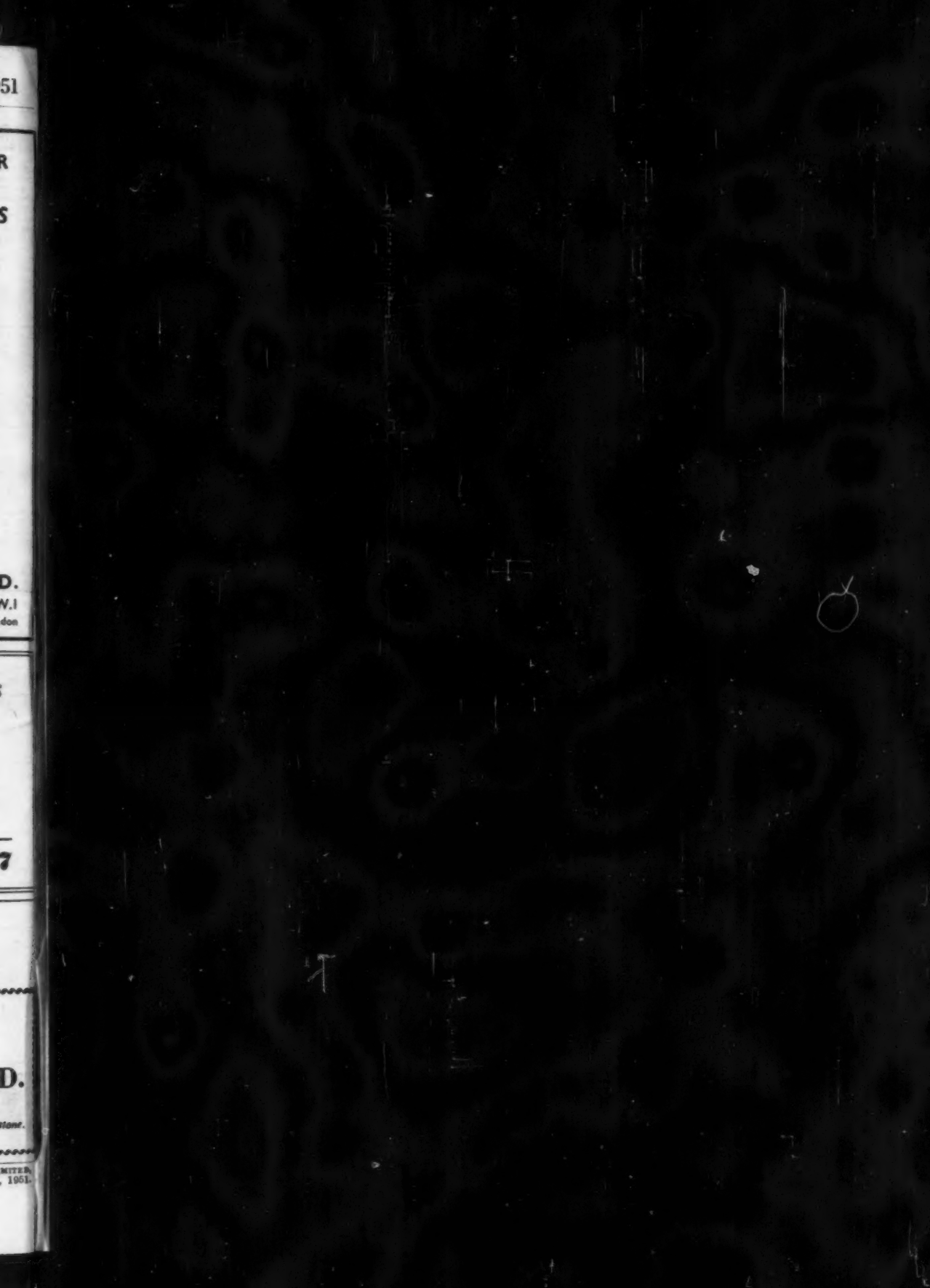
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